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*OBSERVATION AND EXPERIMENT.**

THE near coincidence of this anniversary meeting of the Academy with the end of the nineteenth and with the beginning of the twentieth century imposes peculiar and quite unexpected restrictions in the way of freedom of choice of a fitting subject for an address. Naturally one would like to pass in review some of the brilliant achievements of science in the past century, and perhaps forecast the still more brilliant advances that may be expected to mature in the present century. Especially might one feel tempted to present a semi-popular inventory of the more striking or recondite scientific events with which he is particularly familiar. But all this and more, strange as it may seem, has been done, or is being done, by the public press. Specialists in almost every branch of science have been employed to expound and to summarize the discoveries, the theories, and the useful applications which have rendered science, by common consent, the most important factor in the civilization of the nineteenth century. Statesmen, philosophers and divines are likewise sounding the praises of science and the scientific method with a warmth of recognition and with a stamp of approval which tend to make one who is

*Address of the President of the New York Academy of Sciences, read before the Academy on February 25, 1901.

old enough to have lived in the pre-scientific, as well as in the present epoch, feel as if a millennium were close at hand. Indeed, such a wealth of good scientific literature is just now thrust before us and such a wealth of praise is just now bestowed on scientific achievement that the modest man of science must hesitate before adding a word to that literature or a qualification to that praise.

The requirements of official position are remorseless, however, and one must speak his thought, although silence with respect to science may appear to be the most urgent need of the hour. In view of these circumstances, it seems best to avoid topics of current interest and to invite your attention to a brief consideration of the elements which lie at the basis of scientific investigation and scientific progress. A recurrence to the slow and painful beginnings of knowledge and the first principles evolved therefrom is always instructive; and it is especially fitting at a time, like the present, when the ardor of research is somewhat in danger of the sedative influences which spring from the popular glorification of triumphant successes.

The fundamental data from which all scientific knowledge grows are furnished by observation and experiment. After these come the higher steps of comparison, hypothesis, and finally the correlation and unification of phenomena under theory. Even pure mathematics, though long held apart from the other sciences, must be founded, I think, in the last analysis, on observation and experiment.

Of the infinite variety of phenomena which appeal to our senses, some, like those of sideral astronomy, are subject, in the main, to observation only; while others, like those of terrestrial physics, chemistry and biology, are subject to both observation and experiment. All phenomena are more or less entangled. They point backward and forward in time; any one of them appears and disappears only in connection with others; and the record any one of them leaves is known only by its interaction with others. Out of this plexus of relations and interrelations it is the business of science to discover the conditions of occurrence and the laws of continuity. Happily for man, although the ultimate complexity of phenomena is everywhere very great, it is frequently possible to discern those conditions and occasionally possible to trace out those laws. But the results we reach are essentially first approximations, depending, in general, on the extent to which we may ignore other phenomena than those specially considered. In fact, a first step towards the solution of a problem in science consists in determining how much of the universe may be safely left out of account. Thus the method of approximating to a knowledge of the laws, of nature is somewhat like the method of infinite series so much used by mathematicians in numerical calculations; and as it is a condition of success in the use of such series that they be convergent rather than divergent, so is it an essential of scientific sanity that the mind be restricted by observed facts rather than diverted by pleasing fancies.

The prime characteristic of the kind of knowledge that leads up to science is its dependence on facts which are permanent, and hence verifiable. In the course of the progress of our race there have been certain luminous epochs during which observers and experimentalists have revealed more or less of such knowledge. These epochs have been followed, generally, by others of comparative dullness, or positive darkness, during which fact has been replaced by fancy and what is permanent and verifiable has been eclipsed by what is ephemeral and illusory. It is my purpose

to-night to recall some of the principal events of these epochs, and to enforce, as well as I may, the great lesson they seem to teach us, namely, that science can be maintained only, and can be advanced only, by a constant appeal to observation and experiment.

As we look out on the universe about us the most striking phenomena visible are those which belong to what Galileo and his successors have fitly called 'the system of the world.' The rising and setting of the sun and moon; the majestic procession of the seasons; the splendid array of the stars in the heavens; the ebb and flow of the sea, and the never-ending variety from wind and weather, need only to be mentioned to enable us to understand why astronomy is at once the oldest and one of the most highly developed of the sciences. No classes of phenomena are so obvious, so omnipresent and so enduring. They have furnished the symbols of continuity and permanence for all languages in all historic times. The 'fixed stars,' for example, are in fact, as well as in fiction, our standards of reference in the reckoning of time and space; for are not 'Sirius and Orion and the Pleiades,' as Carlyle has remarked, 'still shining young and clear in their course as when the shepherds first noted them on the plains of Shinar?'

But before astronomy there were mythology and astrology, and we may well marvel how it has been possible, even after the lapse of twenty odd centuries, to educe the orderly precision of science out of the complicated miscellany of fiction, fact, religion, and politics bequeathed to our era by the fertile imaginations of our distinguished ancestors. What, for example, could be more confusing than the paleontological jungle called the stellar constellations, with its gods and godesses; with its dogs, lions, bears and fish, great and small, northern and southern; with its horse, whale and goat; and with the slimy forms of serpents intertwining them all?

Although it is impossible to set any date for the emergence of astronomy out of mythology and astrology, the epoch of Hipparchus undoubtedly is the earliest one of conspicuous advances known to us. This epoch, which may be called also the epoch of the Alexandrian school of science, extends from about 300 B.C. to about 150 A.D. It is distinguished by the remarkably perfect work in pure geometry of Euclid and Apollonius, and by the still more noteworthy work of Archimedes in laying the foundations of statics and hydrostatics; it comprises the measurements according to correct principles of the obliquity of the ecliptic and the dimensions of the earth by Eratosthenes; it includes the observations of the sun, moon, stars and planets collected by Aristyllus and Timocharis and later turned to so good account by Hipparchus; it embraces the work of Aristarchus, who maintained the heliocentric theory of the solar system and who was the first to attempt a measure of the dimensions of that system by means of the fine fact of observation that the earth, sun and moon form a right triangle, with the right angle at the moon when the latter is in dichotomy—or when its face is just half illuminated; and finally it includes the work of Ptolemy, a worthy disciple of Hipparchus, whose Almagest has come down to our own time.

From the observational point of view we must rank the principles with respect to fluids at rest discovered by Archimedes as amongst the capital contributions to the science of all times; for while his successors, of the last two centuries especially, have added to hydromechanics the large and vastly more difficult branch of hydrokinetics, they have found no change essential in his laws of hydrostatics.

Equally important, also, in its far reaching connections was the work of Eratosthenes in determining the size of the earth. This work required an hypothesis as to the shape of the earth and appropriate observations. Supposing the earth to be spherical, an assumption which Eratosthenes knew well how to justify, he saw that to determine its size it is only necessary to apply the rule of three to the measured length of an arc of a meridian and to the measured difference of the latitudes of the ends of such arc. He observed that at the city of Syene, which is about 500 miles south of Alexandria, the sun shone vertically downwards into deep wells at noon on the day of the summer solstice, showing thus that at that place and time the sun was in the zenith. On the same day at Alexandria he observed, by means of the gnomon, that the sun at noon was south of the zenith by one-fiftieth of a circle, or 7°.2. The distance between the two points was found by the royal road masters of the country to be 5,000 stadia, thus giving for the complete circumference of the earth 250,000 stadia. Although the measurements thus made by Eratosthenes were very crude and undoubtedly subject to large errors, we see in them the beginnings of some of the most refined geodetic operations of the present day. Unfortunately for us, also, the measurement of the distance is expressed in a unit whose relation to modern units is only roughly known.*

But commendable as was the work of his predecessors and contemporaries, the work of Hipparchus rises to a still higher plane. He was an observer and a theorist of the highest type, being able at once to collect facts and to interpret their relations, and he deserves to be ranked among the great astronomers of all times. He was the first to clearly appreciate the value of a catalogue of the fixed stars and constructed one giving the relative positions of 1,080 stars. He observed with surprising precision the interval of the tropical year; he made the first tables of the sun and moon; he discovered the remarkable fact of the precession of the equinoxes, and he thus early led the way to the great advances of modern times.

The peculiar merit of the work of Hipparchus lies not alone in the fact that he saw how the apparent motions of the heavenly bodies may be determined by observations, but also in the fact that he saw how these motions may be determined by a very small number of appropriate observations. Thus, for example, the interval from the vernal equinox to the summer solstice and the interval from the latter to the autumnal equinox sufficed to give him a close approximation to the apparent motion of the sun; while the records of a few eclipses of the moon enabled him to deduce a closely correct value of the precession of the equinoxes, that shifting of the line of intersection of the equator and the ecliptic which goes on so slowly that an interval of nearly 26,000 years is required for a complete circuit.

Hipparchus may be called the founder of the geocentric theory, since he demonstrated the accordance of the phenomena known to him with that theory. The fact that this theory is false detracts little from his merits; for the sole requisites of a good theory are simplicity of statement and conformity with observation. We now know, indeed, that mechanical phenomena are, in general, susceptible of multiple interpretations, and that

* As illustrating the slow growth of ideas with respect to precision, it may be related that when the Arabians in the ninth century undertook, for the same purpose, the measurement of a meridional arc on the plain of Singiar, in Mesopotamia, they were not more successful in preserving for posterity the standard of length used by them. This standard is said to have been the 'black cubit, which consists of 27 inches, each inch being the thickness of six grains of barley.'

observation must decide which of them is to be preferred.

The method which Hipparchus used to measure the sun's apparent motion among the fixed stars is very noteworthy, especially when we consider the utter lack of effective instruments in his time. If the sun moves regularly about the earth, as first supposed by Hipparchus, it ought to return at any epoch, as that of an equinox, to the same position among the fixed stars. Imagine a line drawn at the time of the vernal equinox, say, from the center of the earth to the center of the sun. This line prolonged will pierce the celestial sphere in two points, and, if either point can be located, the position of the sun with reference to the stars becomes known. Hipparchus fixed this position by noting the location among the stars of the center of the shadow cast by the earth at the times of eclipses of the moon. By a comparison of his own observations of such eclipses with those made by his predecessors he was able to determine the apparent motion of the sun with reference to the stars, or what we now know to be the motion of the equinoxes with reference to stars. To establish this fact of precession from such meager observations was a great step; and it seems not a little singular that a phenomenon so striking should not have led to speedy investigations for its source. But about eighteen centuries elapsed before Newton clearly visualized the mechanical interpretation of this phenomenon, and it was only after an additional half-century that the interpretation was fully worked out by d'Alembert.

How rapidly the spirit of science dies out when its devotees cease to observe and experiment is shown by the failure of the 'Divine School of Alexandria' to maintain the high standard set by Hipparchus. His immediate successors became at best only commentators. They wrote much but observed little; and it does not appear that any of them attempted even to verify the remarkable discoveries of Hipparchus during the two hundred and fifty years which elapsed between the period of his activity and the advent of his worthy disciple and expounder Ptolemy.

It is to the work of Ptolemy chiefly that we owe our knowledge of the discoveries and theories of the Hipparchian epoch. His treatise on the 'Great Construction,' the Megiste Syntaxis, or the Al Magisti and hence Almagest of the Arabians, is the earliest of the great systematic treatises on astronomy. It is in this work that the theory of eccentrics and epicycles of Hipparchus is explained and elaborated, and it is this work which has given the name of Ptolemy, rather than that of his acknowledged master, to a system of the world which dominated scientific thought for nearly fifteen hundred years.

The period during which the observations and researches of Ptolemy were carried on is commonly referred to in history as extending from the reign of the Emperor Hadrian to that of Marcus Aurelius. Thus, while Ptolemy was an Egyptian by birth, the fact that he was permitted to pursue his astronomical studies under the empire helps to some extent to relieve the Romans of the charge that they were, as regards science, the most ignorant people of antiquity. But the gravity of that charge is only palliated by the work of Ptolemy, for he left no successors. Roman astronomy did not rise above the level of astrology; the spirit of scientific enquiry gave way to speculation and declamation; and the long night which followed was not broken until the dawn of the epoch of Galileo—the modern epoch, whose advances have been founded on observation and experiment.

If astronomy is preeminent among the sciences for its dependence on observation, chemistry and physics are equally preemi-

nent for their dependence on experiment. This difference in methods of investigation between the former and the two latter sciences is a difference imposed by the circumstances that astronomy deals chiefly with objects at long range while chemistry and physics are concerned with objects near at hand. It seems not a little singular, however, at first thought, that progress in the development of knowledge concerning the behavior of distant bodies should have been almost as rapid up to the present time as the development of knowledge concerning bodies much more familiar and accessible to us.

Chemistry and physics, like astronomy, had their forerunners in mythological follies and extravagances. Semi-civilized and civilized man required a long time after he had learned how to talk and to write well, after he had founded states and constructed systems of philosophy and religion, before he could reason rationally and successfully with respect to the commonest material things about him. Thus, chemistry was long obscured by merely verbal speculations on the 'four elements, earth, air, fire and water' or on the 'three elements, salt, sulphur and mercury'; while the beginnings of physics were perhaps even more clouded by the fantastic unrealities of fertile but unchecked imaginations.

But man early learned to measure the value of chemistry by the 'gold standard.' It is hinted, in fact, though without adequate evidence, that the Golden Fleece of the Argonautic expedition was a manuscript containing valuable secrets of the chemist's art; and Suidas, of the eleventh century, to whom the word chemistry is attributed, relates that Diocletian, fearing that the Egyptians, by reason of their knowledge, might become rich and restive, ordered, in true Roman fashion, that their books on chemistry should be burned. The thirst for gold assisted also in the development of alchemy, which flourished from the eleventh to the fifteenth century especially, and has had not a few adherents, it would seem, during all the centuries down to and including the one just past. The philosopher's stone was almost universally believed to be a real agent in medieval times; and this strange fiction also has its survivals in the 'mad stones,' 'moon stones,' 'lucky stones,' and other 'charms' whose use even at the present time is not uncommonly justified by the wise saying that 'there may be something in them.'

The difficulty in getting the human mind started with the elements of physical science is well illustrated, likewise, by the superstitious rubbish that encumbered the early progress of knowledge concerning magnets. They were endowed with imaginary qualities far more wonderful than subsequent observation and experiment have disclosed. It was believed, for example, that they would cause some diseases and cure others; that they were effective as love philters; that they would lose their properties when rubbed with garlic (which seems not so unlikely), but that a bath in goat's blood would readily counteract this destructive effect. And in this case, also, as with alchemy and the philosopher's stone, it is to be noted that such crude notions of the phenomena of matter find their survivals at the present day in a wide acceptance of the unverified efficacy of 'magnetic healers' and 'electric belts,' and in the ease with which capitalists can be persuaded to invest in a 'Keely motor' or in anything that promises the marvelous.

With the decline of alchemy the field for chemistry shifted somewhat. Not unnaturally, since most chemists were also physicians in those days, a knowledge of the chemical properties of substances came to occupy a prominent place in the physician's art. Thus Paracelsus in the sixteenth century, cutting loose from the

teachings of Aristotle and Galen, boldly asserted that the true use of chemistry is not to make gold, but to prepare medicine; and he and his follower Van Helmont, in addition to attaining fame for skill in compounding remedies, were amongst the first to appreciate the true import of the processes of analysis and synthesis which came to be called in their day the spagyric art. Then followed the doctrine of the mutually neutralizing substances, acid and alkali; the fruitful hypothesis of elective attractions, or affinities; the ingenious, if erroneous, theory of phlogiston, and the more permanent theory of oxygen. All these led up through more and more searching experimentation to the first great epoch in the history of chemistry—the epoch of Lavoisier.

Among the early workers in the century preceding the epoch of Lavoisier the names of Becher and his disciple Stahl deserve especial mention, not only by reason of their introduction of the theory of phlogiston, but also by reason of their enthusiastic and steadfast devotion to science without hope of pecuniary reward. In his remarkable treatise entitled 'Physica Subterraneæ,' published in 1681, Becher defends the scientific pursuit of chemistry as not less worthy of attention than philosophical and theological studies. He insists especially on the need of careful observations and on the necessity of constantly verifying theory by experiment. With true scientific enthusiasm he describes the chemist as one willing to work amid the flames and fumes, and, if need be, the poisons and poverty of the laboratory. He has no patience with the charlatans, of which it appears there were still many in his day, who are looking chiefly for ways and means of extracting the precious from the baser metals. As for himself, he says: "My kingdom is not of this world. I trust that I have got hold of my pitcher by the right handle—the true method of treating this study; for the pseudo-chemists seek gold, but the true philosophers, science, which is more precious than any gold."

It is a peculiarly noteworthy fact that while much attention was given to chemistry during ancient and medieval times, comparatively little attention was given to the other branches of physical science. Our knowledge of heat, light, electricity and magnetism is almost wholly a development of modern times. The Greeks were acquainted with a few of the more elementary phenomena of electricity and light; and Ptolemy and Alhazen came near discovering the law of optical refraction; but there was no contribution made to either of those physical sciences comparable with the discoveries of Hipparchus in astronomy until the epoch of Galileo. What a marvelous increase in the rate of scientific progress began with this epoch is shown on nearly every page of the subsequent history of science. Galileo and his contemporaries may be said to have established the methods of observation and experiment. Their systematic application has borne fruit in every science. Almost every step forward has led to additional advances, until now each of the physical sciences has its wide array of determinate facts correlated under a great theory. In the domain of light, for example, the only solid contribution of the ancients is the obvious fact of radiation in straight lines. After nearly sixteen hundred years of our era had elapsed, there came Galileo's invention of the telescope, and about the same time Snell's discovery of the law of refraction. To the telescope was soon added the microscope and the camera obscura. Then followed Newton with explanations of the rainbow, dispersion and kindred phenomena; Hooke with his discovery of the colors of thin plates; Dolland with the

combination of two lenses to produce achromatism, and Huygens with his discoveries and explanations of double refraction and polarization; while in the meantime Roemer had measured the velocity of light. All these accessions crowded one another so closely that the emission theory of Newton and the undulatory theory of Huygens followed almost as a matter of necessity. The battle royal of these two rival theories, as you know, lasted for nearly a century, until the emission theory, by the sheer force of critical observations and experiments, was displaced by the undulatory theory through the brilliant researches of Young and Fresnel.

When we turn from the physical to the geological and biological sciences, the same lessons of the necessity and the efficiency of observation and experiment are still more strikingly apparent. For although geology and biology are the youngest of the grand divisions of science, they have accomplished more than all others toward giving man a proper orientation with respect to the rest of the universe. Geology as we now understand the term is but little more than a hundred years old, and biology, in the sense now attached to the word, is less than fifty years old. Nevertheless, these sciences have been the chief contributors to the doctrine of evolution, which, in view of the wide range of its applicability, must be regarded as the most important generalization of science.

It is a singular circumstance, however, considering the early advances made in the interpretation of the phenomena of astronomy, that the equally ubiquitous and far more accessible phenomena of geology and biology should have been so tardily investigated. The cause of this delay seems to lie in the fact, not without examples in the present day, that our remote ancestors had the habit of constructing their theories first and making their observations, if at all, afterwards; and in the cases of geology and biology they were so well satisfied with their theories that the trouble of making observations was for a long time dispensed with.

We of the present day have no right, perhaps—and I for one would not be disposed to use such a right if conceded—to blame our predecessors for the narrow, and in some instances crooked, views they held with regard to these subjects. But on the other hand, we shall fail, I think, to make proper use of our opportunities if we do not learn speedily to conduct scientific investigations in the future so as to avoid such colossal blunders as mar the history of geology and biology from its beginnings down almost to our own time.

As an illustration of the blunders referred to I may cite the profound reluctance, even of eminent men of science, to accept the plainest teachings of observation with respect to geological time up to the middle of the century just passed. Not until Lyell, the great champion of uniformitarianism as opposed to catastrophism, had published his 'Principles' (1830) did scientific opinion show a tendency to accept the fact of the hoary age of the earth, everywhere attested by the rocks in her crust.

And what a storm of opposition and condemnation, amounting almost in some cases to social ostracism, was visited by the very 'salt of the earth' against those who ventured during the sixties and the seventies of the last century to consider favorably the arguments of the 'Origin of Species'! All this has about it the freshness, and possibly the pain and the humor, of personal recollection for those of us who are old enough to have lived in two epochs. That a mistake of this sort could have been made thirty or forty years ago seems strange enough in these peaceful times of

ours. But while we may properly let the recollection of the storm and stress of this earlier period fade away, the moral of the conflict should be held up as a permanent warning to scientific as well as unscientific men; for no episode in the previous experience of the race demonstrates so clearly the sources of knowledge and the methods of attaining it.

As a final illustration of the validity of my thesis I would invite your attention to one of the most instructive and beneficent of the many brilliant biological researches of recent times. No one who has suffered from repeated attacks of intermittent fever, and has survived the ravages of the materia medica, can fail to take a lively interest in the wonderful progress made during the last twenty years towards a definite knowledge of the natural history of that disease. Nor can any one interested in the general aspects of science fail to see in the investigations leading up to this progress some of the finest examples of the scientific method.

It would appear that malarial fever has been one of the commonest disorders, in certain localities, with which man in his struggle for existence has had to cope; and before the discovery of the properties of Peruvian bark it must have been a very serious affliction by reason of its secondary if not by reason of its primary effects. The symptoms, course and distinguishing characteristics of the disease, as well as the remedies therefor, were long known, however, before it was suspected that the mosquito had anything to do with its dissemination. Bad water, foul air, and sudden or extreme changes of temperature were supposed to be promoting causes. The dampness of marshes, swamps and other areas holding stagnant water was held to be an especially common attendant, if not inducing, condition. There was, indeed, no lack of acute and painstaking observations and no lack of ingenious and well-supported hypotheses with regard to this widely prevalent but obscure disorder. The details of its diagnosis, prognosis, nature and causation, as laid down in the medical manuals of a few decades ago, are particularly interesting and instructive reading now in view of recent developments. For example, Hartshorne in his 'Essentials of the Principles and Practice of Medicine,' published in 1871, gives the following explanations:

"No disease has ordinarily so regular a succession of definite stages as intermittent fever, namely, the cold, the hot, and the sweating stage." * * * "Upon the origin of malarial fevers," he adds, "the following facts seem to be established: 1. They are reasonably designated as autumnal fevers, because very much the largest number of cases occur in the fall of the year. Spring has the next greatest number of cases. 2. They are always strictly localized in prevalence. 3. They never prevail in the thickly built portions of cities. 4. An average summer heat of at least 60° F. for two months is necessary for their development. Their violence and mortality are greatest, however, in tropical and subtropical climates. 5. They prevail least where the surface of the earth is rocky; and most near marshes, shallow lakes and slow streams. The vicinity of the sea is free from them, unless marshes lie near it. 6. The draining of dams or ponds, and the first culture of new soil, often originates them. 7. Their local prevalence in the autumn is always checked by a decided frost."

Here we have the facts with regard to the symptoms and cause of the disease stated with a clearness and a conciseness that could hardly be surpassed. But the real cause of the malady eluded the insight of the discriminating observers who collected those facts. A quite different class of facts required consideration. It was essential

to concentrate attention on the pathological aspects of the enquiry. As to the nature of the disease, Hartshorne writes, with commendable caution, "It is only possible to speculate at present. It is most probable that ague is a toxemic neurosis. The importance of the blood change attending it is shown by the disintegration of the blood corpuscles, and deposit of pigment in various organs." This destruction of the blood corpuscles was the critical point on which the investigation turned. About 1880, Laveran, a French army surgeon, discovered the destructive agency in a minute parasite, one of the protozoa, which takes up its residence in, and then, ungratefully enough, destroys, our red blood corpuscles. What a splendid problem was presented by the facts thus brought to light! The exquisite refinement of the researches which followed may be inferred when we reflect on the minuteness of an organism which can work out a part of its life history within blood corpuscles so small that four to six millions of them find plenty of room in a cubic millimeter. But stranger still is the fact, established within the past year or two, that the mosquito plays the rôle of an intermediary host and transmits the parasites to us while feasting upon our blood. The details of this remarkable discovery need only be alluded to here, for they have been so recently explained by the experts participating in them that their essential features are a part of popular information. Suffice it to remark that they show how we may secure almost complete immunity from malarial fevers at no distant day.

Thus, in whatever direction we look for the sources of scientific progress, the same elementary methods of advancement are found to be effective. Whether we consider the dimensions of the solar system or the distances between the molecules of a gas; whether we seek the history of a star as revealed by its light or the history of the earth as recorded in its crust; whether we would learn the evolution of man or the development of a protozoon; whether we would study the physical and chemical properties of the sun or the corresponding properties of a grain of sand; in short, whether we turn to the macrocosm or to the microcosm for definite, verifiable, knowledge, it is found to originate in and to advance with observation and experiment.

R. S. Woodward.

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*ON THE HOMOLOGIES AND PROBABLE ORIGIN OF THE EMBRYO-SAC.**

The problems connected with the origin and interpretation of the embryo-sac have been of great interest to the student of plant morphology, from the time that they began to inquire into the relation of the ovule to the formation of the embryo plant. It is now a matter only of historical interest that Morland (1702), Geoffrey (1714) and others contended so seriously that the embryo-sac of the angiosperms was a sort of incubator where the embryo, brought in by the pollen tube, was hatched out into the young plantlet. While great advances have been made in our knowledge of the development and function of the embryo-sac, there are still unsettled problems of its origin and homology upon which we speculate, perhaps with no nearer approach to the truth than were the speculations by the founders of the science of plant morphology.

The first important contribution to the morphology of the embryo-sac was made by Hofmeister during the middle of the present (19th) century, extending over a period from 1849 (Die Entstehung des Embryo der Phanerogamen) to 1861 (Neue Beiträge zur Kenntniss der Phanerogamen). In the

* Paper presented before the joint session of Section G, American Association for the Advancement of Science, and the Botanical Society of America, at its sixth annual meeting, New York City, June 28, 1900.

embryo-sac when ready for fertilization he recognized two groups of nuclei lying respectively at the poles, which we now regard as the egg apparatus and the antipodals. At the micropylar end of the embryo-sac Hofmeister found usually two nuclei which he called 'germinal vesicles,' or 'embryonal vesicles,' one of which developed the embryo after the entrance of the pollen tube. In the opposite end he found a variable number of antipodal cells. The embryo-sac was by him considered homologous with the macrospore of the higher Pteridophytes. The germinal vesicles corresponded to the corpuscula (archegonia) and the accompanying rosette of cells (neck) in the gymnosperms.

Schacht (*Jahrb. f. wiss. Bot.*, 1857–8) believed that one of the germinal vesicles received the pollen tube and conveyed it later to the other, or that in some cases a third was present when two germinal vesicles seemed to convey the pollen tube to it. The germinal vesicles were sometimes marked on their surface by parallel folds, or in other cases there were parallel striæ in their contents. These striæ or folds formed his 'filiform apparatus,' which came later to be recognized by Strasburger, Pringsheim and others as homologous with the ventral canal cell of the pteridophytes. This gave rise to a further conception of the embryo-sac which was held by some down to a late period, and even appeared in some of the earlier editions of Sach's *Lehrbuch der Botanik*. In addition to the embryo-sac being a macrospore, it represented a prothallium in which the germinal vesicles formed the archegonia, while the antipodals formed the sterile remnant of the prothallium which was homologous with the endosperm of the gymnosperms.

In 1877–78 there appeared three works, by Strasburger, Warming and Vesque, which mark another important epoch in our knowledge of the embryo-sac. These were concerned with the development of the embryo-sac, and led to new and quite divergent views that have been presented from time to time since that period.

Strasburger (*Ueber Befruchtung und Zelltheilung*, 1877) gave the more complete account of the development of the embryo-sac and the origin of the endosperm, while Warming (De L'Ovule, *Ann. d. Sci. Nat. Bot.*, 6 ser., **5**) and Vesque (Développement du sac embryonnaire des phanerogames angiospermes, *Ibid.*, 6 series, bot. **6**, 1878) were more concerned with determining the origin of the embryo-sac in relation to its homologies with the pollen mother cells. It is not my intention to outline the history of the studies of the embryo-sac further, since it becomes very complex and would be filled with tedious detail. It is my purpose, however, to call attention to the principal theories that have been put forward in the interpretation of the homologies of the embryo-sac.

It should be borne in mind that in reviewing some of these theories of the embryo-sac which have been proposed from time to time, it is done in no spirit of criticism, nor for the purpose of holding up to view, at the present time, interpretations of morphological structures which the authors themselves may not now hold. Undoubtedly they were proposed by the authors as working hypotheses upon which to build further investigations, and it is certain that they all have been very useful in stimulating renewed and more profound researches, with improved methods of technique, and out of it all shall come in the future a clearer insight into the true meaning of these obscure plant structures. It is the history of all progressive science, that theories are proposed as working hypotheses, upon which to build further investigations into the nature of truth. When these have fallen new ones are formulated, for without some formulated idea in the mind, as a working

basis, not as something which we are striving to prove at all hazards, progress in investigation is impossible.

1. The first theory as we have seen was that proposed by Hofmeister who regarded the synergids and eggs as 'embryonal vesicles' or 'germinal vesicles,' and therefore the equivalent of eggs. The supposed variable number of antipodals when they were present represented the prothallium. It is interesting to note that at the present time a number of botanists are coming to recognize the synergids as potential eggs, thus confirming Hofmeister's interpretation of the egg apparatus.

2. The proposal by Schacht (1857–8) of a 'filiform apparatus' suggested by certain folds or striæ on the synergids, which were supposed to act as a conductor of the pollen tube to the egg, led Strasburger (Bef., p. 73, 1877), Pringsheim and others to recognize in this the ventral canal cell. The egg apparatus thus came to be recognized as the archegonium, with the synergids as neck cells, while the antipodals represented the prothallium. This was the prevailing view at that time, and was adopted by Sachs in the earlier editions of his text-book. A very similar view of the embryo-sac has recently been stated by Tretjakow.

3. The third view of the homology of the embryo-sac was the outgrowth of the studies of Warming and Vesque, in which the eight nuclei of the embryo-sac were interpreted as spores, the egg apparatus representing one tetrad, and the antipodals a second tetrad of spores, each spore homologous with the pollen grain. This had its origin in the endeavor of Warming to homologize the processes of cell division in the ovule with those in the anther, both of which were looked upon as sporangia. The larger cell which gives rise to the so-called axile row in the nucellus, and which is either the subepidermal cell, or a derivative of it when a 'tapetum' is present, he called the primordial mother cell of the embryo-sac, and it is so termed by some at the present day. This cell Warming recognized as the young archesporium, comparable with the tetrahedral cell in the young fern sporangium. This primordial mother cell, as is well known, divides into an axile row of several cells, 2, 3, 4, etc. This axile row Warming considered the mature archesporium, each cell being homologous with a pollen mother cell, and he termed them special mother cells. The lower one only developed into the embryo-sac, forming two tetrads, one at either pole, while the other special mother cells disappeared. The egg nucleus is then called the privileged spore. His conclusions here do not appear quite consistent with his hypothesis, since he derives two tetrads (8 spores) from a single special mother cell.

4. Vesque (1879), however, accepting in the main Warming's views, attempts to show that the two tetrads are derived from two special mother cells. The cells of the axile row he regards as the mature cells of the archesporium, that is, special mother cells, and numbers them 1, 2, 3, 4, 5, etc., according to the number present in different species, beginning with the uppermost cell (the one at the micropylar end). No. 1, then, the uppermost cell, divides to form a tetrad, the egg apparatus; while No. 2 forms one or several antipodals, and makes up the larger portion of the embryo-sac. The wall between 1 and 2 dissolves and disappears, so that the embryo-sac is supposed to form by the fusion of these two cells. It is not necessary to dwell further upon Vesque's view, since he gives such an imperfect account of the processes of development which take place here, and since subsequent studies show that in a very large majority of cases it is the lower cell of the axile row which gives rise to the embryo-sac. But it is of interest to note his attempt to harmonize Warming's view

of the relation of the special mother cells to the subsequent tetrads in the embryo-sac, the figure of the tetrad suggesting that each nucleus corresponds to a spore or pollen grain.

5. A fifth view, and one which was also influenced to some extent by Warming, was proposed by Marshall-Ward (*Jour. Micr. Soc.*, **20**, 1880; also, *Jour. Linn. Soc.*, 7, 1880). According to this view the embryo-sac consists of two prothallia, derived from two spores, the egg apparatus representing one, and the antipodals representing the second. The upper one consists of one vegetative cell (the upper polar nucleus) and the rudimentary archegonium, the two synergids being suggested as neck cells. The origin of the embryo-sac according to this view, was as follows: The primary mother cell of the embryo-sac, either a subepidermal cell, or the lower derivative of this, when a tapetum is formed, divides once and forms two cells. The lower one divides again, thus forming three cells in the axile row, separated by cell walls. These three cells correspond to the special mother cells which Warming believed to be homologous with the pollen mother cells. The lower cell now develops the embryo-sac. Its nucleus divides in the same direction as the division walls arising in the formation of the three cells of the axile row. These two nuclei at opposite poles of the young embryo-sac he believed represent cells in the axile row, thus making four cells in all. The two lower cells are not separated by cell walls, due, he believes, to the extraordinary rapidity of growth from this time onward. Each of these two lower cells, represented by the two-nucleated stage of the embryo-sac, he interpreted as a spore, one to give rise to the upper prothallium, and the other to the lower prothallium of the embryo-sac. It is possible to draw the inference that he regards the primary mother cell of the embryo-sac as a mother cell of four spores, since the axile row, as he interprets it, consists of four cells. The two lower ones he distinctly interprets as spores. The primary mother cell could not, however, be a cell homologous with the mother cell of spores according to this interpretation, since three successive divisions occur before these two spores are developed which are to form the embryo-sac; while the tetrad of real spores is developed by two successive divisions.

6. A sixth theory of the homology of the embryo-sac was proposed by Mann. (The embryo-sac of *Myosurus minimus* L., *Trans. & Proc. Bot. Soc.*, Edinburgh, **29**, 35; 1892. The embryo-sac of angiosperms is a sporocyte and not a macrospore, *Ann. Rep. B. A. A. S.*, 782, 1892.) He made an attempt to draw a direct homology between the embryo-sac and the pollen mother cell in origin, and also in the number of nuclei developed as a result of the division of the mother cell or sporocyte. For him each cell of the axile row is a sporocyte, and homologous with the pollen mother cell. Since from the pollen mother cell the four spores (pollen grains) are formed, and each pollen grain at maturity contains two nuclei, making eight in all, he traced a direct and parallel homology in the origin of the eight nuclei of the embryo-sac. The four-celled stage of the embryo-sac represents the four spores which are homologous with the four pollen grains. Each nucleus now divides again into a vegetative nucleus and a sexual nucleus, which correspond to the vegetative nucleus and generative nucleus of each pollen grain. In thus tracing the homology of the eight nuclei of the embryo-sac with the eight nuclei in the four pollen grains, Mann overlooks the fact that prior to fertilization, when the embryo-sac is still in the eight-nucleated stage, the generative cell in the pollen tube has divided again, *or in some cases it divides by the time the pollen is*

ripe, forming twelve nuclei for each pollen mother cell, instead of eight; and thus the homology falls.

7. Another view is that the embryo-sac, at the eight-nucleated stage, is homologous with the endosperm of the gymnosperms or, in other words, that the eight free cells are homologous with the endosperm of the gymnosperms. This was proposed by Strasburger as early as 1879. One of the cells of the endosperm forms the archegonium which here is very much more reduced than in the gymnosperms, being reduced to a single cell. A suggestion of such a reduced archegonium is found in Welwitschia, etc., where a single endosperm cell without division elongates to form the simple archegonium. Guinard ('81, *Ann. d. Sci. Nat. Bot.*) upholds this view.

8. Very closely allied to this view is the one which interprets all the cells at the eight-nuclear stage of the embryo-sac as potential eggs. Dodel ('91) found in *Iris siberica* that the synergids were sometimes fertilized, and developed embryos. He suggests that the synergids are potential eggs. Chamberlain, '95, suggests that one of the antipodals has all the appearance of an egg ready for fertilization. Strasburger (*Ang. und Gyn.*, '79) states that while in *Santalum* the normal number of eggs is two, there are sometimes three, and one of these may be the upper polar nucleus, when the endosperm is developed from the lower polar nucleus. Overton ('92) records a case of fertilization of one of the synergids of *Lilium martagon;* Guinard ('81) the development of embryos from two synergids in *Mimosa denhartii*, and Tretjakow ('95, *Ber. deut. Bot. Ges.*), the development of embryos from the antipodals of *Allium odorum*. Tretjakow interprets this as a case of apogamy, since he regards the antipodal cells as representing the vegetative portion of the prothallium.

In view of all the facts, Strasburger's hypothesis that the eight cells of the embryo-sac are homologous with the endosperm of the gymnosperms, seems the more reasonable one. If the synergids, then, can be fertilized and produce embryos, they too represent archegonia reduced to a single cell each. This would confirm the view first proposed by Hofmeister that the synergids and egg are 'germinal,' or 'embryonal vesicles.' Tretjakow holds that the antipodals represent the vegetative part of the prothallium, while the synergids and egg represent archegonia, which is very like the earlier views held by Strasburger, Pringsheim and others.

But if the eight cells of the embryo-sac are homologous with the endosperm of the gymnosperms, and the egg is an archegonium reduced to a single cell, it would seem that all the cells of the embryo-sac are potential eggs or potential archegonia.

It is probable that all the peripheral cells of the endosperm in the Abietineæ, for example, at a certain stage of development, a short time prior to fertilization, are potential archegonia. While the archegonia are usually developed from superficial cells at the micropylar end of the endosperm, they are frequently formed from superficial cells down on the side some distance from the end, giving to the endosperm in longitudinal section the appearance of a comb. Archegonia are in some cases developed at the opposite end of the endosperm which would correspond in position to the antipodals of then agiosperm-embryo-sac. Furthermore, archegonia are rarely developed from internal cells of the endosperm. This would indicate that prior to the time for fertilization all the cells of the endosperm are potential archegonia.

And this too seems reasonable since up to this time the course of development in all parts of the gymnosperm embryo-sac have been the same, all parts bear the same nutritive relation to the surrounding nucel-

lus. No part functions particularly as the vegetative part, or protonema, as is the case with most of the pteridophytes. The true vegetative function of the endosperm appears later. The fact that the archegonia do usually arise at the micropylar end of the endosperm is probably acquired or hereditary, since archegonia there are more certain to be fertilized.

If, therefore, the eight-celled stage of the angiosperm embryo-sac is homologous with the endosperm of the gymnosperms, then all the cells are potential eggs. The functional egg is at the micropylar end of the embryo-sac, because the chances for its being fertilized here are greater. This is true of the synergids also when they become functional eggs. The antipodals probably appear in this rôle very rarely. Nevertheless, potentially they are eggs, or greatly reduced archegonia. If this be so, then an embryo developing from an unfertilized antipodal cell would fall in the category of parthenogenesis, instead of apogamy.

This, however, may be drawing the line very fine, and I am not so much concerned with that fine distinction as I am with the *probable origin* of the embryo-sac. Since the embryo-sac has been recognized as the female prothallium of angiosperms, it is natural that there should be an effort to interpret it as a derivative from a macrospore. It is derived, according to the different interpretations of its homologies, from a different number of macrospores.

According to the Vesque theory, it consists of eight macrospores derived from two cells of the axile row, a fusion of two-spore mother cells. According to the theory proposed by Mann it consists of four macrospores and is derived from a single cell of the axile row, regarded as a spore mother cell (sporocyte). According to the theory suggested by Marshall Ward, it consists of two macrospores, each representing a prothallium of four nuclei, the two spores derived from the third cell in the axile row by a division in which no cross wall is formed. This cell of the axile row then would represent a *one-half spore mother cell*, or if the *number of divisions from the primary mother cell be taken into account it would represent a single spore*.

The theory that it consisted of eight spores was shown long ago by Guinard ('81) to be untenable. It necessitated the fusion of two spore mother cells. Vesque had little in support of his theory, since he considered the embryo-sac to be formed by a fusion of the two upper cells of the axile row, while as a matter of fact the embryo-sac arises from the lower cell in all except a very few cases. Although Marshall Ward found no evidence of a cell wall separating the two nuclei in the first division of the embryo-sac mother cell, he regarded these as representing two cells of the axile row.

There have been recent attempts to show that the embryo-sac in some cases is derived by a fusion of two cells of the axile row, where a weak or temporary cell wall is formed after the division of the nucleus (Wiegand, '98, in *Convallaria*). This, however, is more properly to be classed with the phenomenon so often exhibited in free-cell formation, where a temporary cell plate is laid down to be soon dissolved, and as often occurs in the first division of the pollen mother cell of different plants. Guinard ('81), in addition to citing this phenomenon as evidence that the embryo-sac is not formed by a fusion of two cells, adduces other strong evidence against it. In *Agraphis patula* (Mellink, '80) the axile row consists of two cells and the upper cell forms the embryo-sac, as Campbell ('99) has recently shown to be the case in *Peperomia pellucida*, while in Caltha, according to Mottier ('95), with a three-celled axile row, the upper one sometimes forms the embryo-sac. In *Narcissus tazetta* (Mellink, '80) there are two cells in the axile row.

The nucleus of the upper one undergoes repeated division without, however, forming the embryo-sac, which develops from the lower cell. Fischer ('80) reports a similar case in *Melica nutans* with an axile row of three cells; the two upper ones each contain two nuclei, and yet the embryo-sac is developed from the lower. Similar cases Guinard ('80) found in *Cercis*, *Phaseolus*, *Erythrina*, Miss McKenney ('98) in *Scilla*, and Wiegand in *Convallaria* (1900). The cells of the axile row with several nuclei, Guinard points out, are undeveloped embryo-sacs. Their nuclei divide several times in adjacent cells, but the intervening walls do not dissolve and permit the fusion of the two cells of the axile row to form the embryo-sac, which is always developed from a single cell. Other examples are known, like that shown by Strasburger in *Rosa livida*, Benson in *Fagus* and *Carpinus*, where *several embryo-sacs side by side, or one above the other, begin to develop and attain considerable size, but do not fuse.*

The weight of evidence then goes to show that the embryo-sac is developed from a single cell of the axile row, though this row may consist of but a single subepidermal cell, as in *Lilium*, *Tulipa*, etc., or of two, three, or four cells, as in other types.

If this single cell, the mother cell of the embryo-sac, or macrospore, is the homologue of a spore in a strict morphological sense it would be necessary to show that it is derived by the same, or similar, processes of development. In those plants where the axile row consists of four cells, the cells might be regarded as tetrads, or spores, one of which develops the embryo-sac, while the others degenerate. But their axile arrangement, so constant in all spermaphytes, is against that supposition, and indicates that the course of development of these cells is more in keeping with the development of adjacent nucellar tissue. The axile arrangement itself, however, would not constitute a bar to their homology as spores. But in plants where the axile row consists of but two cells, or one cell, not even such a slight suggestion of their homology with spores is presented.

So far as investigation has been made, there is evidence that the development of spores in the bryophytes and pteridophytes, and in the development of the pollen in the spermaphytes, from a mother cell, is accompanied by nuclear phenomena known under the head of reduction of the chromosomes. It has been suggested that the reduction of the chromosomes in the formation of the embryo-sac might be employed as a criterion to determine what constitutes the spores. The facts, however, which have been obtained in the few cases investigated do not offer any more hopeful evidence as to the identity of the spores. In *Lilium*, and other observed cases, where the single cell develops directly into the embryo-sac, the reduction takes place in the first division. In other cases where an axile row of two, three or four cells is formed, the reduction of the chromosomes, so far as I know, always takes place in the primary mother cell of these, several cell divisions removed from the beginning of the embryo-sac. This is what we should expect, since this cell undergoes a maturation period prior to the formation of the axile row. So, whatever criterion we employ to determine the identity of the spores, we are led to irreconcilable confusion; either that the embryo-sac just prior to fertilization consists of 1, 2, 4 or 8 spores, or that it is developed in some plants from a spore representing one-fourth of a mother cell or sporocyte; in other plants from one-half of a mother cell, and in still others from the entire mother cell.

It is clear then that there do not exist here spores in the sense in which they are represented in the pteridophytes, or in the microspores of the spermaphytes; neither in actual form, nor according to processes

of development. How then does the embryo-sac of angiosperms arise? It arises directly from the nucellar (sporangial) tissues or from the archesporium, without the intervention of spores. In the pteridophytes such phenomena are classed under the head of *apospory*. The origin of the embryo-sac directly from sporangial tissue, considered only from the standpoint of the absence of spores, would also fall under the general category of apospory. But apospory merely does not indicate the real morphological significance of its derivation. It is to be interpreted as an adaptation of the plant in developmental processes under the influence of the changed and peculiar environment of the gametophyte, which has become so general in the angiosperms, and probably in the gymnosperms also.

There is no longer any need of spores, as such, in the development of the female prothallium of angiosperms. Where spores exist, as such, they exist for the purpose of distribution of the plants, as in the bryophytes and pteridophytes; in the spermaphytes for the distribution of the male prothallia, so that they may be lodged in a position where the sperm cells may reach the egg. There is a law in the evolution of organisms and organs, that when an organ or structure is no longer needed as such, it tends to disappear. Spores are not needed in the development of the embryo-sac. They are therefore cut out of the cycle of development, and the embryo-sac, or gametophyte arises directly from the tissue of the sporophyte.

In suggesting that the origin of the embryo-sac is a kind of apospory, we do not mean that it is phylogenetically connected with cases of apospory in earlier forms, nor that it is derived from them, nor that apospory as a phenomenon is continuous through groups. We simply mean that there has been a shortening in the process of development here, before the formation of the spores, just as there has been a shortening after the beginning of the gametophyte, and it has gone so far that the spore, *as such*, *i. e.*, a spore which is formed by the accompaniment of the same phenomena which we know to prevail universally where we can recognize a definite spore, is *wanting*.

There is no need that such a spore or cell should be formed, because the necessity for it has disappeared. A cell, however, is formed which is not the morphological equivalent of a spore, but is the physiological equivalent, and develops the embryo-sac. The process is shortened so that the spore is cut out, and perhaps the mother cell forms the embryo-sac directly, a new development of a prothallium, or body functioning as such, directly from sporogenous tissue.

If Vines' suggestion (Student's Text-Book of Botany) that in *Asclepias* each cell of the pollinium is a mother cell, is correct, we should have a similar shortening process in the development of the male gametophyte. But this suggestion may not, possibly, be supported by the facts when we know the course of development of the pollinium and sperm cells in *Asclepias*. But we can conceive of a hypothetical case where a mechanism might arise for transporting the archesporium from an anther to the pistil bodily, and that the reduction in the anther had consequently gone so far that the tetrad divisions of the mother cell to form spores had ceased, now that there is no need for the individual and separate spore. The cell of the archesporium might form the pollen tube or male prothallium *directly*, cutting out the spore. This would be apospory so far as the loss of the spore is concerned. Its significance, however, would be greater. It would represent a new attainment in the evolution of the male gametophyte, quite independent of any phylogenetic relation to processes of development in earlier gametophytes.

The condition of things, however, in the ovule is very different from what it is in the anther, because early in the evolution of the spermaphytes the necessity for a definite spore for distribution disappeared, as the ovule retained the gametophyte within its nucellar tissue. The time has been long enough for the complete elimination of the spore. But in the case of the anther or microsporangium, the process has perhaps only begun; or perhaps it would be better to say that the conditions are being ushered in, in some cases where pollinia are formed, which in time may result in the elimination of the microspore from some of these forms.

In the elimination of the spore from the macrosporangium of the spermaphytes, they have arrived at a new morphological attainment, the development of the embryo-sac or gametophyte, directly from the archesporium or nucellus. The gametophyte of the angiosperms is very simple and rudimentary compared with that even of the gymnosperms, a few free cells, perhaps all of them potential eggs. Being free and few of them, they are in intimate relation with each other and are more subject to the secondary influences of fertilization than the endosperm cells of gymnosperms are.

Perhaps, for this reason, the angiosperms have arrived at a second and more remarkable morphological attainment, in the development of the second endosperm subsequent to fertilization. The interpretation of this may lie partly in the results of 'double fertilization,' and related phenomena, when the second sperm sometimes unites with one of the potential eggs, or with the 'endosperm nucleus' to form the second endosperm, or may possibly itself sometimes form a separate endosperm. It is well known that in the pteridophytes and gymnosperms often several eggs are fertilized in one prothallium, and several embryos begin to develop. Finally one of them usually outstrips the others, which then atrophy. In the angiosperm embryo-sac the potential eggs are all free and so situated that they are immediately and profoundly influenced by fertilization of the 'privileged' egg.

The endosperm nucleus, or one of the other potential eggs, being fertilized by the second sperm, may be so immediately influenced that, instead of developing into an embryo which in a short time would be outgrown and destroyed, it is directed into a new channel of development, which has resulted in the evolution of a new plant generation to be utilized as a nutrition body by the privileged embryo. If the secondary influences of fertilization in angiosperms have acted somewhat in this way, it might account not only for the retarded development of the so-called 'endosperm' in the angiosperms, but also for some of the phenomena known under the expression *Xenia*.

Geo. F. Atkinson.

NATURAL HISTORY WORK AT THE MARINE BIOLOGICAL LABORATORY, WOOD'S HOLL.

Natural history has been a growing element in the work of the Biological Laboratory at Wood's Holl. All departments represented at the Laboratory have made contributions in this field. Life histories have been studied principally in connection with embryological research, as, for example, in Conklin's work on 'Crepidula,' Lillie's on '*Unio*,' Mead's on 'Annelids,' Foot's on 'Allolobophora,' Clapp's on the 'Toad-fish,' Patten's on '*Limulus*,' Wheeler's on 'Insects,' Watasé's on the 'Fireflies,' etc. Within the last few years natural history studies have acquired wider and more independent interests with us. Animal behavior has engaged the attention of a number of investigators, led by Loeb, Wheeler, Thorndike and others. The demand for instruction followed the development of various lines of research, and the courses in general physiology and animal psy-

chology were, so to speak, spontaneous inevitables. The course in nature study, introduced for the first time last summer, furnished a typical illustration of the convergence of interests now cooperating at the Laboratory. Although the class only numbered fifteen members, over thirty investigators contributed to the instruction given, and a large share of the lectures, laboratory work and field studies were of the nature of research. Indeed, problems and demonstrations drawn from original work actually in progress, and presented by the investigators themselves, characterized the course throughout.

In the further development of this course in natural history, we are looking forward to hoped-for facilities far beyond our present realizations. The creation of a Natural History Farm at Wood's Holl may be somewhat remote still, nevertheless the project is entertained, and a small step has already been taken in anticipation. The columbarium now under cultivation is, I venture to hope, the first instalment of such a farm. This collection of pigeons, already the largest of the kind in existence, and rapidly increasing by accessions from all parts of the world, was undertaken with several ends in view. The pigeon group, containing between four and five hundred wild species, and not less than one hundred and fifty domestic species or varieties, offers one of the most favorable fields for the comparative study of variation and for experimentation in dealing with the problems of heredity and evolution. While the principal aim in making the collection was the investigation of problems, the farm project has been kept steadily in view. The columbarium would form one section of the farm, and exemplify its uses and unique advantages for every side of natural history.

Ever since the second birth of natural history in Darwin's 'Origin of Species,' the need of experimental work on *living* animals has been clearly seen. The two elements of success in such work are *control* and *continuity*. Both elements would be secured in an institution that combined efficiently organized laboratories and a farm stocked, manned and equipped for experimental research.

The idea of such an institution was elaborated a long time ago in the 'New Atlantis,' in which is described a model college and farm instituted for the experimental study and interpretation of nature. This model was esteemed too vast and high for imitation, and the great and marvelous things it promised only served to emphasize its dreamland picturesqueness. It was only after the doctrine of Natural Selection had taken a deep hold of the scientific world, that Lord Bacon's dream found an echo in the schemes proposed independently by Romanes and Varigny.

The question of the transmutation of species stood foremost in the minds of these naturalists, and it seemed as if the world would never be quite convinced without experimental tests of a crucial kind. For such tests it was obvious that plants and animals must be studied as living things; that the conditions of life and propagation must be such as could be precisely defined and made to vary in ways admitting of control; and that the work must be carried continuously forward from year to year. Out of these requirements arose the idea of an experimental farm.

General biology, or modern natural history, is now seen to stand in pressing need of something like the model college of Bacon's *Nova Atlantis*, embracing not only an experimental farm, but also laboratories and a strong body of investigators with a competent staff of assistants. Naturalists everywhere appear to be fully awake to this important need, and Professor Meldola (*Nature*, Feb. 13, 1896) did not ex-

press too strongly the general conviction when he declared—"The one great desideratum of modern biology is an experiment station where protracted observations can be carried on year after year on living animals."

The ideal plan would certainly make the farm an integral part of a natural history institute, according to the idea of the Baconian model; and herein may be seen the propriety of the name, 'Baconian Institute of Experimental Evolution,' proposed for such a foundation by Professor Osborn.*

An institute organized to meet the common needs of naturalists, and supported as a biological center—conditions approximated at Woods Holl—would obviously supply a strong combination of forces, and so ensure to a natural history farm its higher utilities as a source of scientific discovery and of unparalleled facilities for instruction.

C. O. Whitman.

CHRISTIAN FREDERIK LÜTKEN.†

The death of Professor Lütken of Copenhagen removes one of the last of that band of eminent zoologists whose long and active lives cast such luster on the Scandinavian countries throughout the last century.

Christian Frederik Lütken was born in Sor on October 4, 1827, the son of Professor Johannes Christian Lütken, Reader in Philosophy at the Academy there. It was during his last year's study at the Academy, which he entered in 1844, that young Lütken was induced by the lectures of Hauch and Steenstrup to turn seriously to zoology; and this he pursued when he passed to the University of Copenhagen in 1846. There he came in contact with Liebmann, Forchhammer, Ibsen, Eschircht, H. C. Oersted, and 'again Steenstrup, who was in the same year appointed professor of zoology at the University. Lütken's zoological studies were, however, interrupted by the troubles of 1849–50 (first Schleswig-Holstein war), when he served as a volunteer and took part in the battles of Ullerup and Isted. He was accorded permission to complete and publish his first scientific work during the winter 1849–50, and in 1852 finally left the army to fill a place as assistant in the Zoological Museum of the University, taking the degree of Magister in the following year. The position at the small University Museum was neither assured nor well paid, but it was improved some ten years later, when the Royal Museum was joined with that of the University to form the existing Museum of Natural History, in the second division of which (dealing with fish and lower animals, except Arthropoda) Lütken served as assistant to Steenstrup. It was not till the death of J. Reinhart in 1882 that he obtained an independent appointment as Inspector of the First Division, which was now made to include all vertebrates. After Steenstrup's retirement, on January 28, 1885, Lütken was appointed professor of zoology at the University and thus became chairman of the Museum Board, while he continued to direct the Division of Vertebrata. In 1885 he married his cousin Mathea Elizabeth Müller, who died in 1890, leaving no children. Some five years later Lütken's own energies began to yield to attacks of illness; in the summer of 1898 he had a paralytic stroke from which he never recovered; he therefore retired from his official posts at the beginning of 1899, and after a long struggle finally succumbed on the 6th of February at the age of 73.

Lütken's labors fall under the heads of museum work, education and descriptive zoology.

The Zoological Museum of Copenhagen,

* 'From the Greeks to Darwin,' p. 93.

† Much of the personal matter in this notice is gleaned from an article by H. F. E. Jungersen in *Illustreret Tidende* (Copenhagen) for February 17th. The article is accompanied by an excellent portrait.

with which he was connected for 47 years, is greatly indebted to his organizing power, and was constantly benefited by the friendly relations that he maintained with his colleagues in other lands. This was the branch of his work for which he was peculiarly fitted by his patience and accuracy, and to which he was most attracted. Among the gifts which, from very slender means, he contrived to make to the museum may be mentioned a valuable collection of fossil mammals.

For a teacher, and particularly a lecturer, Lütken was less qualified. His manner was reserved and unsympathetic, his style too literary. These defects were scarcely counterbalanced by the thoroughness with which he prepared his lectures. His great text-book, 'Dyre-riget,' published in 1855, was stuffed full of facts, laboriously collected and verified, but lacked the simplicity required in an educational work. This fault was remedied in the briefer manuals familiar throughout Danish schools as 'Lütkens, Nos. 2 and 3.' Indeed, as a writer for the public, Lütken could be clear enough. In addition to many popular sketches of animal life, he, together with C. Fogh and Chr. Vaupell, edited the 'Tidskrift for populære Fremstillinger af Naturvidenskaben,' which had a remarkably long life for a magazine of that nature, namely from 1854 to 1883. This literary interest took him away from the open-air studies of marine zoology that he had begun in his student days, while his museum duties led him still more to the 'dry bones' of his subject. Recognizing his own deficiencies, he succeeded in obtaining an annual grant for the founding of a Biological Station, where, under the guidance of younger men, his students could take a biological course. As a member of the Fishery Board also he successfully urged on the Government the need for a detailed study of the natural conditions of Danish waters before any legislation could be effective.

As a museum assistant Lütken's technical zoological writings were inevitably confined to the description and classification of the material in his charge. Corals, jellyfish, crustaceans, isopods, annelids, ascidians, blindworms, all came beneath his survey, but his chief work lay among echinoderms and fishes. In the former group his doctoral thesis 'On the Echinodermata of Greenland, and the geographical and bathymetric distribution of that class in northern seas' (1857) holds a foremost place. He wrote also on starfish, sea-urchins and West Indian crinoids, but his chief systematic work was done on the ophiurids. In this department he has of late found an able fellow-worker in Dr. Th. Mortensen. In ichthyology his earliest work of importance was on the classification of the Ganoids, the complete memoir appearing in 'Palæontographica' (1873–75). While describing and classifying the numerous fish that came to him from all parts, but chiefly from northern seas, he was by no means unmindful of wider questions, as was proved by his most important work 'Spolia Atlantica,' of which the first part, published in 1880, discussed the changes of form in fish during their growth and development. The second part, issued in 1892, dealt with the distribution of the phosphorescent patches in certain deep-sea fishes, and is thus alluded to by Goode and Bean in 'Oceanic Ichthyology': "Dr. Lütken's masterly and exhaustive paper on the Scopelids of the Zoological Museum of the University of Copenhagen * * * has rendered it necessary to completely revise our opinions upon the relations of the species."

All Lütken's work, like that of so many of his Scandinavian contemporaries, was marked by thoroughness, accuracy and a wide knowledge of previous writings. Al-

though well acquainted with foreign languages and a writer of good English (as proved by his contributions to the *Zoological Record* from 1872 to 1878, and by his admirable article on Steenstrup in *Natural Science* for September (1897), he preferred, as a rule, to publish in his native language. This, while a benefit to the Danish school, has not prevented foreign zoologists from recognizing the value of Lütken's work; abstracts have appeared in many English and other journals, and honors have been showered on the author. His death causes a vacancy in such societies as the Royal, Linnean and Zoological Societies of London, the Imperial Academy of Sciences of St. Petersburg, the Imperial and Royal Zoological and Botanical Society of Vienna, the Boston Society of Natural History and a vast number for whose names we have no space.

Lütken was a tall and handsome man of the fair Danish type, with a keen blue eye. His upright and somewhat stiff demeanor might be a reminiscence of his military service. But his reserve did not prevent one from seeing the thorough worth and single-mindedness of his life and thought, nor did it check his really kind disposition, as experienced not only by his family and closer friends, but by every foreign visitor to him in his Museum at Copenhagen, and every correspondent who sought his aid.

F. A. B.

SCIENTIFIC BOOKS.

PROGRESS OF FOREST MANAGEMENT IN THE ADIRONDACKS.*

THE recent report of the Director of the New York State College of Forestry and the College Forest in the Adirondacks is a document of more than ordinary interest, dealing as it does with questions that are now engaging the attention of the legislatures of several States and to which much thought is being given by citizens who are interested in the public welfare.

As shown by the report, the number of students has increased from four, the number three years ago, to twenty-five and, in addition to these regular students, there are registered twenty-nine from the Colleges of Architecture, Civil Engineering and Agriculture. The five students who went out from the school last year have found satisfactory employment, three with the Forestry Division of the United States Department of Agriculture, one with a lumberman's firm and one with the Forest, Fish and Game Commission of the State of New York.

In addition to the work of the three professors of forestry, many of the professors and instructors in other Colleges of Cornell University have aided in giving instruction, and lectures on fish culture have been given by Dr. B. W. Evermann, of the United States Fish Commission, and a short course in practical timber-estimating was given at Axton by Mr. C. P. Whitney, a well-known estimator, while courses on marketing the forest crop, as well as special courses in law and engineering, have been arranged for.

The plan of requiring practical work of the junior and senior classes in the College Forest has proved satisfactory and has become a permanent arrangement. The work embraces inspection of logging operations, timber estimating and measuring, surveying and locating roads, nursery work and planting, marking trees for cutting, practical work in the sugar orchard, and excursions to fishing grounds and hatchery.

Aside from this, the distinctively educational work of the College, the problem of the management, development and satisfactory utilization of the forest property — thirty thousand acres in the Adirondacks—with which the College is entrusted has been fairly met. It involves securing a market for the wood, much of it already past maturity and rapidly deteriorating, and the perpetual renewal of the forest by planting or natural regeneration, so as to provide both for future cutting and improvement of the property. The widely different conditions under which European forestry is prac-

* Third Annual Report of the Director of the New York State College of Forestry, Ithaca, N. Y., March, 1901.

ticed make it an impossible guide in the present case, except as to principles, while the manner of their application has taken perforce the form of original experimental study of a most difficult problem.

The director ably defends the policy of harvesting the crop as carried out at the College Forest, a policy made possible by special legislation, which has permitted the entering into contracts for the disposal of the old and decrepit hardwoods forming the bulk of the culled forest. Such contract has been made with the Brooklyn Cooperage Company, under which a stave and heading factory and a wood alcohol plant are being erected at Tupper Lake and connected by rail with the College forest. The prices obtained are fair market rates, better than private owners of similar property in the Adirondacks have been able to get the present year, and the experiment, in spite of an unusually unfavorable winter, promises to be self-supporting. It is expected that about 50 per cent. of the area cut over during the time covered by the report will have to be planted. White pine and Norway spruce will be employed, using both plants and seeds, and adding elm and ash, with a few other species.

Various important questions have arisen in connection with the actual and possible yield of Adirondack hardwoods, and these, together with the ideals and practical limitations of American forestry, are carefully discussed. It is shown that the American market is the essential factor which makes the practice of forestry as a business different in the United States from that of Germany, and that this, again, is due to the difference in density and distribution of population. Accordingly, the German wood market is mostly local, steady and continuous. A sustained annual yield is the best business policy, and a thorough utilization down to the small brush is possible through local consumption by the dense poor population. The American wood market, on the other hand, is essentially continental; the harvest is transported to centers of consumption, and cheap transportation over long distances is the keynote of marketing it profitably. This requirement in many districts rules out a thorough utilization of the product, and inferior parts of the harvest must be left unused. Hence a realization of the theoretically 'normal forest' with a so-called 'sustained yield' is at present impracticable in America from a business point of view. And, moreover, unfair systems of taxation discourage the attempts at such management that otherwise might be made. The working plan of the College, therefore—carrying out the aim of the management to attain the best that is attainable under existing conditions—is simply to remove the old crop as fast as the market and practical considerations permit, and replace it by a crop of better composition and promise; *that is, to practice silviculture.*

The basis of an American system of forestry is summed up in three primary essentials:

1. Better protection of forest property, including rational methods of taxation—a subject of legislation.

2. More thorough utilization of the forest crop—a subject of wood technology and development of means of transportation and harvesting.

3. Silvicultural methods of harvesting, so as to produce a desirable new crop, or else artificial reforestation—the main concern of forestry.

Planting operations on burnt areas have been continued and there are now ninety-five acres planted, chiefly with white pine, Douglas spruce and Norway spruce, the last named having thus far proved most satisfactory as to cheapness, rapidity of growth and endurance of drought and frost. Two nurseries have been established in which already about a million seedlings of various conifers have been raised for use in planting and for experiments in acclimatization. An experienced forester, whose professional education was had in Switzerland, is in charge of all the technical work, such as supervision of felling, planting and nursery work, conducting of experiments, collecting of data and statistics, and making reports, while the purely business arrangements, such as hiring of labor, purchase and sale of materials, care of property, and the book-keeping and sealing are in charge of a superintendent familiar with such duties. A logging foreman of experience is in charge of the crew and camp, supervising the labor. The College is now in a position to dispose annually of upwards of 15,000 cords of wood for fuel and

the retort, and from 2,000,000 to 4,000,000 feet of logs. The fullest possible utilization of the entire product down to the branchwood, two inches in diameter, has been accomplished, and even the brushwood has been employed to some extent in the production of wood alcohol and in other ways.

That so extensive a series of operations should have been embodied in an actual system of forestry, for which there are no existing models, that a market should have been created and the experiment conducted with good prospect of being self-supporting from the start; that in a country thus far without schools of forestry that could be drawn upon for trained men, and with the practical difficulties attending the importation of foreign specialists, it has been possible to equip and conduct such a school and forest, is sufficient testimony to the ability of the director, who, in the face of extraordinary difficulties, has successfully conducted an undertaking never before attempted, and one of immense importance and promise.

Aside from its value to the State of New York, which has liberally maintained it, the establishment of the school and the College Forest is a matter of great moment to such other States as are immediately concerned with forestry problems and are contemplating necessary legislation. V. M. Spalding.

Zoological Results based on Material from New Britain, New Guinea, Loyalty Islands and elsewhere, collected during the years 1895, 1896 and 1897, by Arthur Willey. Cambridge, Eng., the University Press. 4to. Part IV. 1900. Pp. viii + 174; pls. 20.

The fourth part of Dr. Willey's 'Zoological Results' contains ten contributions covering a wide range of topics. The first is by J. S. Gardiner and deals with a supposed new species of coral, *Cœnopsammia willeyi*. A very full description of the anatomy of this animal is given and some interesting conclusions concerning its germ layers are drawn. The actinozoa are usually described as covered externally with ectoderm, which at the mouth is reflected inward so as to line the gullet. From the inner end of the gullet the ectoderm is continued as mesenteric filaments over the free edges of the mesenteries. The walls of the gastrovascular cavity are usually said to be lined with entoderm. Gardiner points out that digestion does not take place in the gastrovascular cavity of these animals, but in the so-called gullet whose deep end is imperfectly closed by the mesenteric filaments. The cell lining of the gastrovascular spaces, instead of being concerned with digestion is made up of epithelial muscle cells and of genital cells. These conditions have led Gardiner to redefine the limits of the germ layers in the anthozoa. The layer covering the exterior of the animal is the ectoderm. At the mouth the ectoderm is continuous with the layer lining the gullet and giving rise to the mesenteric filaments. As these are the parts chiefly concerned in digestion, this layer is the entoderm. The lining of the gastrovascular cavity, muscular and reproductive in character, is the mesoderm. Thus the actinozoan is not a diplo-blastic, but a truly triplo-blastic animal.

The paper is well illustrated and the two text figures which show the relations of the calcareous skeleton to the soft parts in *Cœnopsammia* will be welcomed by teachers in general as well as by students of the corals.

The second contribution is a report on the insects of New Britain, by D. Sharp. It consists of notes on some fifteen species of beetles, and on several bees, wasps, and flies. One of the wasps collected, probably *Polistes colonicus*, had the strange habit of laying several eggs in a cell, though in the end only one mature insect emerged from each cell. How the supernumerary larvæ were disposed of and whether this habit was an individual peculiarity or a characteristic of the species were not determined.

Borradaile's account of the crustaceans shows that eighty-two species of stomatopods and macrurans were collected and that twenty of these were new to science.

The slugs were studied by W. E. Collinge, from whose work it appears that six species were found, two of which were new. One of these, *Veronicella willeyi*, is made the basis of a full anatomical study.

According to E. G. Philipps sixty-three species of Polyzoa were collected, of which nine were new. L. R. Thornely notes thirteen species of

hydroids, ten of which have never before been described.

J. J. Lister presents an extended report on a peculiar hard white organism found growing on dead coral in thirty-five fathoms of water. It was made up of a continuous skeleton of solid polyhedral elements penetrated by a system of anastomosing canals; these were lined with soft tissue and were open to the exterior. The soft tissue contained here and there what seemed to be large unsegmented eggs and other masses which had the appearance of parenchymular larvæ. Taking all these peculiarities into account, the author believed the organism to be a sponge, but of so unusual a structure as to justify the erection of a new family for its reception. The species is called *Astrosclera willeyana*, and the family Astrosclerida.

A series of embryo mound birds and one hatched nestling are reported on by W. P. Pycraft. The feather tracts of the embryo and the nestling plumage are described in detail. The birds are able to fly almost upon hatching, and this has led to the idea that they were at once provided with adult plumage. Pycraft points out that their plumage is not adult, though it is also not true nestling down.

S. J. Hickson and I. L. Hiles report on certain of the octocorallia, two species of Stolonifera and twenty species of Alcyonaria, three of which are new. The Xeniidæ are described by J. H. Ashworth. Of the sixteen known species of soft corals belonging to this genus, Dr. Willey's collection contained representatives of four, as well as material upon which the description of a new species is based.

G. H. PARKER.

The Austin [Texas] Dam. BY THOMAS U. TAYLOR. Water-Supply and Irrigation papers of the United States Geological Survey, No. 40. Washington, Government Printing Office. 1900. Pp. 52, pl. xvi.

In this publication Professor Taylor, of the Engineering Department of the University of Texas, gives an account of the inception, building, and failure of the 'Austin Dam,' a municipal undertaking for the purpose of controlling the water supply of the Colorado River.

The first foundation stone was laid May 5, 1891, and the disaster, due to an unprecedented flood, occurred April 7, 1900.

As remarked by Mr. F. H. Newell, in his letter of transmittal, "There are many useful lessons to be drawn from the history of such an enterprise, for it often happens that failure is more instructive than success. Throughout the United States many communities are now discussing the utilization of water power for irrigation and other industrial purposes, and they may be saved from mistakes or be led to adopt precautionary measures by a clear understanding of the causes of the disasters which have occurred through the neglect of certain precautions."

The scope of the paper may be seen from the following general headings: Introduction, Preliminary Projects, Construction of Dam, Leak under Head Gate, Flow of Colorado River, Economic Aspect, Silting of Lake McDonald (the body of water back of the dam), Failure of the Dam. The illustrations are both numerous and excellent, some being from photographs taken immediately after the accident.

Among the errors pointed out are the following: That the minimum flow of the river had been greatly overestimated, hence the power developed upon the completion of the dam fell far short of that hoped for; that evaporation as a factor had almost been lost sight of, that the engineers in charge of the work of construction (the dam cost $611,345.29) had been hampered and interfered with in the prosecution of their labors; and that the geologic conditions prevailing at the site had been ignored. To these errors are attributed the failure of the enterprise to meet the expectations of the public and its failure as an engineering feat.

While Professor Taylor's paper is of the greatest interest to the engineering profession, there is much of value in other lines, as, for instance, the carefully conducted investigation of the silting up of Lake McDonald.

FREDERIC W. SIMONDS.

February 19, 1901.

SCIENTIFIC JOURNALS AND ARTICLES.

THE *American Geologist* for January contains an article by S. E. Bishop on 'Brevity of Tuff

Cone Eruptions.' The discussion is devoted principally to the formation of the cone Leahi, or Diamond Head, in Honolulu, which the author claims, and attempts to prove, was formed by an extremely rapid projection aloft of its material for a few hours, ceasing suddenly and finally. The article is accompanied by a plate. 'Possible new Coal-Plants, etc., in Coal,' Part III., by W. S. Grisley, Erie, Pa. The writer describes and figures about fifty fossils which he thinks may be coal plants hitherto undescribed. Most of the forms described come from a coal bed in Iowa. Mr. John Dresser discussed the 'Petography of Mount Oxford,' a large igneous mass in the Green Mountains of Vermont. The main part of the mountain consists of graywacke, serpentine, ophicalcite and sandstone. A paper follows 'On Some Newly Discovered Areas of Nepheline Syenite in Central Canada,' by Willet G. Miller. In a very interesting paper on 'Peneplains of the Ozark Highlands,' Oscar H. Hershey discusses the life histories of certain parts of the Ozark region. The changes may be briefly put as follows: (1) The entire region was reduced to base level forming cretaceous peneplain. (2) A great dome-shaped uplift occurred in the southern two-thirds of the region, and it was base-leveled again during the Tertiary. (3) A general uplift throughout the Ozarks, which was again eroded and base-leveled in some places during the Pliocene. (4) Another general uplift, greatest in southern Missouri. (5) A local uplift of the Boston Mountains during the modern epoch. Following are the 'Reviews of Recent Geological Literature' and 'Personal and Scientific News.'

In *Popular Astronomy* for April Herbert A. Howe continues his discussion of astronomical books for the use of students, taking up general popular works, descriptive text-books and handbooks. Professor Harold Jacoby, of the Astronomical Observatory of Columbia University, writes under the title of 'The Astronomer's Pole,' of the work to be done at the new Helsingfors Observatory. Illustrations of the instruments and building accompany the article. Anderson's 'New Star in Perseus' is the subject of several articles, and notes. Circular No. 56, from the Harvard Observatory, by E. C. Pickering, with reference to the Nova is printed in full; the first chart and catalogue for observing it is given by J. G. Hagen, S.J., of the Georgetown College Observatory, Washington, and Dr. H. C. Wilson, of Goodsell Observatory, adds much to the general information of the Nova, and includes a chart of its light curve. Shorter articles are by R. W. McFarland, on 'Ancient Eclipses and Chronology'; by Dr. George Bruce Halsted on 'Astral Geometry,' and by A. E. Douglass, on 'Photographs of the Zodiacal Light'; the latter is accompanied by an excellent plate. Eclipse cyclones are discussed, and there is a translation of H. Arctowski's article on 'Northern and Southern Lights illuminating the Heavens at the Same Time,' which recently appeared in *Ciel et Terre*. Planet, spectroscopic, comet and asteroid notes occupy the usual space. Among the 'General Notes' are the following: Board of Visitors at the Naval Observatory, Trouble at the Naval Observatory, Naval Observatory Legislation, Observations of Nova Persei at Seagrave Observatory, At Yerkes Observatory, At Ladd Observatory, At Vassar College Observatory, At Pomona College, Notation of New Variables, Nomenclature of Variable Stars, Crocker Eclipse Expedition to Sumatra, Spectrum of ζ Puppis, Evanescent Star Photographs.

In Italy has just appeared a new mathematical journal, issued at Città di Castello, by the publisher, S. Lapi, to whom the annual subscription, 12 francs, should be sent. It is a monthly magazine, called *Le Matematiche*, under the direction of Professor C. Alasia, with a board of collaborators, among whom the English language is represented by G. B. Halsted, of Austin, Texas, to whom communications may be sent, which will appear in Italian. On the editorial board may also be noted the Russian, Vasiliev, and the greatest of living mathematicians, Poincaré. The first number, February, 1901, contains the last thing written for publication by the illustrious Hermite, dated January, 1901, on the 14th of which month he died. The magazine has a suggestive new department, headed 'Subjects for Research.'

We have received with pleasure the first number of *School Science*, a monthly journal

devoted to the teaching of science in secondary schools, edited by C. E. Linebarger and published at Chicago, Ill. There are twelve associate editors, all teachers in secondary schools, and the contributions given in the first number and promised are chiefly from teachers in secondary schools, though the present number contains contributions from Professor Palmer, of the University of Colorado, and Professor Nichols, of Cornell University. The journal is evidently edited with care, and will exert an excellent influence.

SOCIETIES AND ACADEMIES.

ANTHROPOLOGICAL SOCIETY OF WASHINGTON.

THE 314th meeting of the Anthropological Society was held on March 12th.

Dr. J. Walter Fewkes presented some historical documents, consisting of a fac-simile of the map of Padre Menchero (1747) of the territory now embraced in Arizona and New Mexico; a fac-simile of the map of Juan de la Cosa (1500), showing the famous demarcation line of Pope Alexander II. and the discoveries in the New World at that period, and an unpublished manuscript of Antonio Alzate, describing the ruins of Xochicalco, Mexico. The Menchero map, which is rare and little known, gives the locations of the missions in the Southwest, and valuable ethnological data. It was issued at Berlin. The Cosa map was copied during the Columbian Historical Exposition at Madrid in 1892-3 from the original lent by the Vatican. Dr. Fewkes pointed out that Alzate was the first to call attention to the need for preserving the ruins in Mexico.

President W. H. Holmes presented instruments of execution and torture, exhibiting an iron cage found some years ago by workmen engaged in road building in King George County, Virginia. This cage is constructed roughly on the outlines of a human body, and on discovery contained a human skeleton, most of which is still preserved. Mr. Holmes said that no documentary evidence has yet been found of 'hanging in chains' in the United States. He called attention to a similar gibbet found in Jamaica and stated that this form of post-mortem exposure of the bodies of criminals is English, and was practised as long ago as the twelfth century. The last gibbet was constructed and used in England in 1832. There is no very reliable record of the hanging of living persons in these cages, although tradition has it that such was the practise. At the close of his remarks Mr. Holmes exhibited a large collection of instruments of torture brought to this country from Hanover, Germany, by Anton Heitmuller, of Washington.

The first paper of the evening was entitled 'Ethnology in the Jesuit Relations,' by Mr. Joseph D. McGuire. Mr. McGuire has carefully gone over the collection of Relations, recently published under the editorship of Reuben Goldthwaites, extracting all ethnologic and archeologic data. This paper is the first of a series having in view the rehabilitation of the American Indian at the period of first contact with the white man, as far as can be done by examination of the literature. Mr. McGuire's paper was listened to with much interest.

Mr. W J McGee's paper on the 'Cocopa Indians' occupied the remainder of the session. Mr. McGee went into considerable detail as to the arts and customs of the Cocopas, whom he visited last summer. The custom of burning the house of the deceased, and the communistic division of the property among the friends, exclusive of the relations, in the event of a death, coupled with the periodical removals from the flood-plain of the Colorado to higher ground, and *vice versa*, have exerted a profound repressive influence on the Cocopas. These Indians were found to be at a low ebb numerically and physically, and are without doubt rapidly tending to extinction.

WALTER HOUGH.

THE SCIENCE CLUB OF UPPER IOWA UNIVERSITY.

THE last regular meeting of the Club was held February 27th. Arthur E. Bennett described his researches among the prehistoric remains of New Mexico, including skeletons, utensils, pursuits, pottery, decorations, worship, etc. He stated that the plain, mesa and cliff dwellers were really one people. At the next meeting he proposed to discuss the prob-

able cause of extermination of these people. He has spent four summers on the ground.

A second paper, read by Bruce Fink, was an ecologic study of the swamp vegetation of northern Minnesota. *Marchantia*, *Sphagnum*, the conifers, the heaths and the orchids were especially considered. No less than thirteen species of orchids collected in these swamps were exhibited, and it was incidentally stated that fourteen species have been collected within ten miles of the University at Fayette, Iowa.

SCIENCE CLUB OF THE UNIVERSITY OF WISCONSIN.

The regular monthly meeting of the club was held on March 1st, at 7:30 P. M., President E. A. Birge presiding. The program of the evening consisted of an address by Professor Ira Remsen, of Johns Hopkins University, on the subject, 'The Outlook in Chemistry.' The speaker emphasized the importance of the researches of such men as Cavendish, Scheele, Priestley, Lavoisier, Berzelius, Liebig and Wöhler. He characterized the work of Lavoisier as revolutionary, and stated that since his time such revolutions have not marked the progress of chemistry. The advance of chemistry, and of other sciences as well, was spoken of as taking place in waves. After the important, fundamental work at the close of the eighteenth and the beginning of the nineteenth century came the activity in organic chemistry, while at present a large amount of energy is directed to physical chemistry in particular. After mentioning some of the triumphs of synthetic work in organic chemistry, Professor Remsen expressed the opinion that a long time would still have to elapse before all the various products of organic beings could be prepared in the laboratory. An audience of about five hundred persons listened to the lecture, which abounded in food for thought interspersed with appropriate anecdotes and witticisms.

Louis Kahlenberg.

THE ELISHA MITCHELL SCIENTIFIC SOCIETY.

At the 133d meeting of the Society, on March 12th, in the Chemical Lecture Room of the University of North Carolina, the following papers were read:

'A Marsupial Track in the Triassic,' Professor Collier Cobb (by title).

'A New and True Antidote for Carbolic Acid,' Professor E. V. Howell.

'Yellow Fever and Mosquitoes,' Professor R. H. Whitehead.

'The World's Production of Iron and Steel,' Professor Chas. Baskerville.

Chas. Baskerville,
Secretary.

DISCUSSION AND CORRESPONDENCE.

THE DATE OF RAFINESQUE'S DEATH.

Editor of Science: In looking over some back numbers of Science quite a year old, I have happened upon the interesting letters between Rafinesque and Professor Wagner as given by Mr. T. L. Montgomery in Science for March 23, 1900. I do not know how I came to miss this item of so long ago, else this note would have been sent you in earlier reply.

The date of Rafinesque's death is correctly given by me in my 'Life and Writings of Rafinesque' as September 18, 1840. I am aware and at the time was aware of the date September 18, 1842, as cited by Mr. Montgomery. I also am aware that all the dates he cites from the various authorities he names are incorrect and all started from the same original error. Evidently an overlooked typographical error in the original publication was the cause.

If Mr. Montgomery had looked carefully at the certified copy of Rafinesque's will, which forms the end of my volume, he would have noted that on November 16, 1840, the signature was attested as being that of Rafinesque by two persons, James Henry Horn and Sam Hood; that on November 28, 1840, James Mease, as executor, was duly sworn for that office and each of the above facts dated in November, 1840. Of course it is hardly necessary to say that wills are not probated two years before a man dies.

The date 1842 is often found in biographical notices of Rafinesque, but all seem to originate in the error of the first notice. I have always imagined that date to be a typographical error. My authority for 1840, as the year, is the will

of Rafinesque probated in November of that year.

R. ELLSWORTH CALL.

BROOKLYN, N. Y., March 14, 1901.

LUNAR HALO.

TO THE EDITOR OF SCIENCE: On February 25, 1901, there was visible in this locality a lunar halo of rather peculiar form. After vain attempts to find an explanation of it the writer asks the privilege of an appeal to the readers of SCIENCE. This phenomenon consisted of an elliptical ring around the moon with axes apparently about six degrees and nine degrees respectively. The principal axis of the ellipse was vertical while the terminator of light on the moon's surface made an angle of about 45 degrees with the horizon. The moon was about half way down in the southwest and half full. A southeast breeze was blowing and very thin fleecy clouds could be seen passing over the face of the moon. The ring persisted for fifteen minutes or more.

The peculiar orientation of the terminator and major axis is the difficult part to explain. One might expect an elliptical though perhaps ill-defined ring from an elongated source of light, but why should the major axis be inclined to the terminator?

C. M. BROOMALL.

MEDIA, PA., March 23, 1901.

SHORTER ARTICLES.

THE LARGEST KNOWN DINOSAUR.

THE Field Columbian Museum paleontological expedition of the past summer was fortunate in securing a number of Dinosaur bones belonging to an animal unique both in size and in proportions. These bones consist of a femur, a humerus, a coracoid, the sacrum, an ilium, a series of seven presacral vertebræ, two caudal vertebræ, and a number of ribs. Part of this collection has been placed on exhibition and the remainder will follow from time to time as the work of preparation proceeds.

The most striking characteristic of this animal, so far developed, is the relative length of the front and hind legs. While the humerus of *Brontosaurus excelsus* Marsh is a little more than two-thirds as long as the femur, the humerus of the individual in question is decidedly the longer bone of the two.

The femur is a stout bone with expanded condyles and a head not constricted from the shaft. The specimen is somewhat crushed antero-posteriorly, but otherwise in a fine state of preservation. Its greatest length parallel to the axis of the shaft is 80 inches (2,003 m.), which is six inches longer than the femur of Marsh's *Atlantosaurus*. The humerus is broad at the proximal end, but unusually slender in the shaft. It has suffered somewhat from weathering, so that the entire surface of the distal end has flaked away, leaving a firm chalcedony core. In this condition its length is equal to that of the femur; with the articular end complete it would probably exceed it by two or more inches. Its present length is greater by 23 inches than the longest humerus hitherto known to science.

The coracoid is broad and straight at the scapular articulation, but less massive than that of *Brontosaurus*. The sacrum is made up of four coossified vertebræ, having small lateral cavities in the centra. A complete rib, presumably from about the sixth presacral vertebræ, measures more than nine feet in length. Some of the thoracic ribs have a secondary tubercle, and also a foramen leading to a cavity in the shaft. However, these may not prove to be constant characteristics.

The similarity of the femur to that of *Atlantosaurus*, together with the presence of but four vertebræ in the sacrum, suggests that this animal may belong to that group. The writer does not feel justified in creating a new genus until the material shall have been sufficiently worked out to make an accurate determination possible. However, the evidence at hand is sufficent to show that we have here to do with an animal which differs radically from any well-known Dinosaur. The extraordinary length of the humerus, together with the size of the coracoid, suggests an animal whose shoulders would rise high above the pelvic region, giving the body something of a giraffe-like proportion. The relatively smaller size of the anterior caudal vertebræ indicates a lesser development of the tail than is common among the sauropod

Dinosaurs. Along with these proportions we may well expect to find a correspondingly shorter neck and perhaps an animal fitted for arboreal food habits. Such a short-necked type was long since suggested by Marsh in his *Apatosaurus laticollis.**

In a future publication of the Field Columbian Museum a complete description of this most interesting Dinosaur will be given.

ELMER S. RIGGS.

FIELD COLUMBIAN MUSEUM,
March 16, 1901.

A RECENT FAULT-SLIP, OGDEN CANYON, UTAH.

IT is generally known that the western face of the Wasatch range, Utah, is determined by a profound fault, and that numerous minor faults are observable at the base of the range. At the mouth of Ogden canyon these secondary faults are particularly plain. Recently there occurred at the locality named a very slight slip along one of the minor fault planes. The movement opened a crack in a mass of gneiss through which a tunnel has been cut as a part of the conduit pertaining to the Ogden Power and Light Company's generating plant. The tunnel walls were fractured, a crack averaging one and a half inches appearing on the inside. The escaping water found outlets on the mountain side at depths of from fifty to a hundred and fifty feet below the tunnel floor, and in its course it carried down many tons of boulders and debris. A steel bridge over the Ogden river was completely destroyed. The disturbance was strictly local, and apparently was due to the escape of water from the tunnel down the plane of faulting, thus constituting a column which by hydrostatic pressure further shifted the block. As to expansion through freezing being the probable cause, there is none but negative evidence. Repairs are in progress. These consist in the removal of the upper part of the shifted block, and in carrying a wooden pipe line through the tunnel.

It appears that the water was first seen issuing from the side of the mountain below the tunnel within a few days after the occurrence of a slight earth-tremor in the vicinity. In the loose alluvial deposits along the mountain front on the north of the canyon mouth, cracks and subsequent settlings have appeared.

J. E. TALMAGE.

* *Amer. Jour Sci.*, Vol XVII., p. 87.

QUOTATIONS.

THE U. S. NAVAL OBSERVATORY.

THE Secretary of the Navy has temporarily ended the Naval Observatory troubles, without the aid of a court of inquiry or court-martial, by detaching Professor Stimson J. Brown from the institution. * * * It would seem from this that Secretary Long shares with Capt. Davis, the superintendent of the Observatory, the belief that Professor Brown transgressed the naval regulations in his efforts to have Congress pass the legislation needed to make the institution a great national one, and not a mere adjunct to the navy. As Capt Davis's tour of shore duty expires before long, a new superintendent may be looked for within six months, and peace in the Observatory may be expected until the new superintendent and new director of astronomy come to a parting of the ways. Meanwhile, scientists all over the country are being urged to come to the rescue of the Observatory by bringing pressure to bear upon Congress. A bill which met the approval of SCIENCE was introduced in the Senate in the last session by Senator Morgan. It provided for the nationalization of the Observatory and for the appointment as director of an eminent astronomer, 'to be selected from the astronomers of the National Academy of Sciences, unless in the judgment of the President one of higher scientific and executive qualifications be found.' Friends of the institution should see to it that a similar bill is introduced at the opening of the next Congress and vigorously pushed to passage.—The N. Y. *Evening Post.*

POLITICS AND STATE UNIVERSITIES.

To form a just conception of the working of the State university, we should go to the older States of the Central West, where State universities have long been in existence, and where they have had time to shape, in a measure at least, public opinion on university education. In this part of the country the four most conspicuous and liberally supported State universities are those of Michigan, Illinois, Wisconsin

and Minnesota. In these States the tenure of the university president compares very favorably with that of any other class of educational institutions in any part of the country. Among the conspicuous college presidents of the United States, President Angell stands next in seniority to President Eliot, of Harvard. The presidents of these four State universities have served terms varying from seven to thirty years, and averaging over fifteen years. The significance of this long tenure of office is apparent, if we recall the uncertain and fluctuating fortunes of the two great political parties in these Northwestern States during the last ten years.

A particularly striking instance of the development of public opinion against political interference may be found in Illinois. In the year 1894 the State University was subject to the management of a Board of Trustees, consisting of nine elective and three *ex-officio* members. Of the nine elective members of the Board, six were Democrats, as were also at least two of the three *ex-officio* members. One of these two, a member in fact as well as in name, was Governor John P. Altgeld, the vigor of whose partisanship no one will question. In spite of this decisive Democratic majority in the Board of Trustees, that body elected as the new president of the University a gentleman who was well known as a member of the opposite political party, and who had held, a few years before, a conspicuous and responsible position in the party councils of another State. * * *

The freedom of university teaching will probably always stand in need of jealous defenders. No human institution can secure itself absolutely against all influences in restraint of truth, some of which are none the less serious because they are not of a kind to attract public attention. Yet, all things considered, the State universities of the Central West may fairly claim to have made a good stand for non-partisan treatment of university teaching.—*The Independent*, N. Y.

CURRENT NOTES ON PHYSIOGRAPHY.

SNAKE RIVER CANYON.

SOME brief account of the great canyon of Snake river is presented by W. Lindgren (The gold and silver veins of Silver city, de Lamar and other mining districts in Idaho, '20th Annual Report, U. S. Geological Survey,' 1900, pt. 3, 65–256, numerous plates and figures), supplementing the description given a few years ago by Russell (U. S. Geological Survey, Water-Supply and Irrigation Paper, No. 4, 1897). Where the river forms the western boundary of Idaho, the lava plateau has an elevation of from 6,000 to 7,000 feet; its successive flows, revealed in the dark brown canyon walls, are from 20 to 150 feet thick. Hereabouts, the river has cut down into the pre-lava mountains, the contact revealing a buried surface of strong relief. The canyon walls for a depth of 2,500 feet are benched on the horizontal lava beds; a remaining depth of the same amount is steeply buttressed with porphyries and diorites. "The bottom of the old valleys clearly lie far below the deep cut of Snake river, how far is not known. * * * It may be confidently advanced as a working hypothesis that this whole district * * * far from having been elevated since the Tertiary era * * * represents an area of depression, standing now at lower levels than during the Miocene period" (93).

ALPINE MORPHOLOGY.

A MONOGRAPH of unusual interest and value is found in E. Richter's 'Geomorphologische Untersuchungen in den Hochalpen' (*Pet. Mitt.*, Erg'heft 132, 1900, 103 p., 6 pl., 14 fig.).

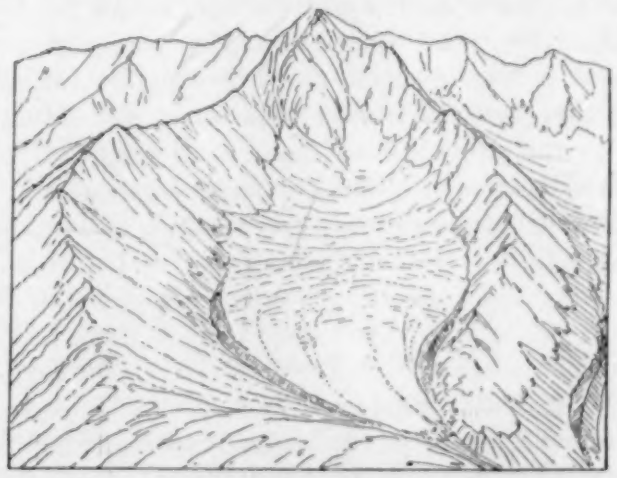

FIG. 1.—A corry beneath a sharp peak with serrate spurs.

It is concerned particularly with the origin of Kahre (cirques, corries, botner), which consti-

tute so characteristic a feature of the high Alps: arm-chair-like recesses in the mountain slope, frequently arranged in groups all backing towards a central peak or an axial ridge and separated by sharply serrate spurs. Valley troughs are also considered, and these as well as the Kahre are referred to glacial erosion under conditions that are critically specified. Among many important conclusions are the following: The high Alps, rising above the snow-line of the glacial period, owe their form largely to the destructive processes of that time. Whole ranges, 100 kilometers long, exhibit sharp high-mountain forms, with corries and serrate spurs, although they bear no glaciers at present. If it had not been for the glacial period, these ranges would to-day have the rounded forms appropriate to mountains of middle height. During the most extensive glaciation, the Swiss ice-fields stood so high—even over the forelands towards the Jura—that they were above the level of the snow-line; the slope of the snowy surface was gentle and the movement of the ice-streams in the larger valleys must have been slow. The trough form that obtains in all the strongly glaciated valleys —with over-deepened floors and over-steepened walls—is due to erosion by glaciers of medium size, whose surface did not rise above the trough walls, but whose movement must have been relatively rapid because their surface slope was strong. Ice-scouring during maximum glaciation reached far up the mountain slopes above the trough walls, but was without great influence on form. A level of extensive erosion is seen in the high Alps, coincident with the snow line of the glacial period; the peaks that rose above this level were actively consumed by weathering, while the surrounding valleys were smothered in heavy but slow-moving ice.

NEW ZEALAND.

The ninth volume of the *Bibliothek der Länderkunde*, entitled 'Neuseeland' by R. von Lendenfeld (Berlin, Schall, 1900, 186 p., 24 pl. and fig., map), is a very attractive volume from which one may gain a clear impression of the country dealt with. Limiting this note to sections of a physiographic nature, mention may be made of Banks peninsula, a dissected volcanic group, standing in front of the Canterbury plains, with which it is connected by long tangential sand reefs. A tunnel cut through one of the volcanic slopes has disclosed 174 different layers; lava, loose or compact, conglomerate, and weathered soil. The Canterbury plains, composed of recent fluviatile deposits brought from the mountainous background, have a gentle slope seawards; the flooded rivers build up their surface with coarser deposits near the mountains and finer deposits near the shore; as their channels become clogged, the water deserts them for new courses, thus the whole surface is slowly aggrading. The account of the fiords of the southwest coast mentions their numerous waterfalls, but one must read between the lines to see that the falls leap forward from hanging valleys, such as now appear to be characteristic of strongly glaciated mountains. A striking example of such a valley seems to be shown in the plate of Mitre peak, Milford sound (fiord). The volume has a good index, but the pages are headed only with their numbers, in German fashion. The frontispiece of Mount Tasman and the Hochstetter glacier is remarkably fine.

W. M. Davis.

CONTEMPORARY THERMODYNAMIC EFFICIENCIES.

This is the day of remarkable things in the field of heat-engine construction. The *Inchdune*, and a sister ship on the 'Inch Line' of a well-known British steamship company, has produced the horse-power-hour on 0.96 pound of coal and, for the time, holds the world's record in steam-engine efficiency. This gives an efficiency, between the coal-pile and the point of transformation into power of the potential energy of the fuel, of almost precisely twenty per cent.

The steam-turbine is produced in such perfection of design and construction as to compete with the best of reciprocating engines of similar power and the report now appears in the German engineers' *Zeitschrift* that Jacobson, at Potschmühle, has tested a Laval Turbine which, rated at 300 horse-power, demands

but 7 kilograms per horse-power-hour at its rating, a trifle more at 342 delivered horse-power, and, a most remarkable achievement, at one-tenth its rated power only increases the consumption of steam to 9.74 kgs. This is better than any record yet reported for the reciprocating engine in maintenance of efficiency with diminishing delivery. The steam-pressure was about 8.5 atmospheres. Superheating gave about ten per cent. gain. The speed of the machine was about 10,000 revolutions a minute. A condenser was employed.

The Engineer-in-Chief of the U. S. Navy, Admiral Melville, reports in his annual message to the Department a remarkable set of data from the trial of the water-tube boilers of the U. S. S. *Cincinnati*. Steam was raised from cold water to a pressure of 215 pounds in 12 minutes, 40 seconds and without injury. The old shell-boiler would have needed several hours for getting up steam and, if forced, would have been expected to develop leaky tubes in all directions. After steam was up, the series of trials reported on was made, with forced draught, fuel being burned at rates ranging between 20 pounds, as a minimum, to above 50 pounds, per square foot of grate area, and with resulting evaporation of water of from nine pounds per pound of fuel, at the minimum, to 8.6 at the maximum rate of combustion. This is the equivalent of from 12.19 to 11.43, 'from and at' 212° F., per pound of combustible portion of the fuel, an efficiency of boiler of from 85 to 90 per cent. The coal used was of the Pocahontas variety, which contains ordinarily but two or three per cent. of ash. Here the ash and refuse in unburned coal and clinker amounted to about ten per cent. This is the most remarkable performance of which we have record. The evaporation is excellent at the lowest rate of combustion and wonderfully well sustained through the higher ranges. It probably constitutes a world's record to date.

Gas and oil and petroleum-vapor engines are also coming to the fore in a remarkable way and the beginning of the twentieth century already commences to show the quality of the new era in these directions Mr. H. A. Marshall has recently presented a paper to the British Institution of Mechanical Engineers, now just published, in which he gives the outcome of investigations of the efficiencies of the gas-engines employing 'power-gas' of the Mond variety, differing from the well-known Dowson gas in the fact that it is made from bituminous 'slack,' instead of from anthracite. It requires the use of enormous quantities of steam—250 per cent. of the weight of the fuel—and makes a very lean gas; but it employs so cheap a grade of fuel as to furnish the unit of heat at an unprecedentedly low cost. It makes 150,000 cubic feet of gas per *ton* and this yields 2,000 horse-power-hours in large gas-engines of good construction. A by-product, ammonium sulphate, more than recoups the original cost of the fuel, with the English coals used. The outcome of this improvement and of the adoption of the gas-engine in large sizes for extensive work is that, whereas the cost of fuel for the ideal steam-engine of modern practice should not exceed about a half-cent, the real engine demands, as a minimum, one cent, and the average engine of the large British stations one and a half-cent, or more; while the gas-engine has come down to a considerably lower cost than the minimum just given. The figures for heat-units demanded are reported as about 25,000 B. T. U. per horse-power-hour for the best steam-engine and but 11,500 for the gas-engine, under best conditions and continuously working. The real comparison is necessarily that of costs of production of the unit of power and it is this relation which will ultimately determine the supremacy of one of the competing heat-engines.

Gas-engines are now built in large powers—1,500 H. P., and larger powers can be readily supplied if called for—and are found to involve less practical difficulty on the large than on the small scale. They are now durable, regulate well and are economical in use of exceedingly cheap fuels. The results obtained at Winnington, as reported by Marshall, are, in fact, not only better, thermodynamically, than those given by any existing steam-engine, but are even better than even the ideals of the case brought into the comparison; all of which are engines in use in English power and lighting

stations. The actual weight of fuel used at Winnington is one pound per h.-p.-h. This is substantially the same as the figure for the record-breaking steam-engine in marine practice already referred to; but the latter uses the most costly, the gas-engine the least expensive, fuel, and this is the vital matter. The gas-engine now has attained a mechanical efficiency of about 85 per cent. and a thermal efficiency exceeding 25 per cent.; both figures representing the practical limit in steam-engine practice also, although the former is sometimes exceeded. In both engines the efficiency, on the basis of the brake horse-power, is about twenty per cent., occasionally one or two units higher.

The Mond gas, with a thermal content of 150 *B.T U.* per cubic foot, sells for twopence per thousand; this can be compared with our own illuminating and natural gases, storing 600 and 1,000 *B. T. U.*; of which, respectively, 16 and 9 cubic feet are used in good gas-engines, per horse-power-hour, while of the Mond gas at least 75 cubic feet are demanded.

Summing up the case: It may be said that the best work of the large gas-engine gives a thermal efficiency substantially the same as that of the very best steam-engine while it employs a fuel which is considerably cheaper than is employed where this comparison is, as here, made on the basis of fuel consumed. Its 'cost of plant,' on a large scale, is now quite as low.

The balance sheet of the best single gas-engine reported stands thus:

	Heat transformed, *B. T. U.*.....	33.65
Heat received from the fuel *B. T. U.* 100.	Heat lost	
	Cylinder-jacket.....	19.28
	Piston.....	4.94
	Exhaust valve.....	3.34
	Total in cooling water...	27.00
	Heat waste in exhaust, etc.	38.79
		100.00

This is superior to any steam-engine performance yet reported.

During the discussion, Mr. Donkin reported in tabular form the best results of tests of gas-engines made in the United States with natural gas, the richest gas-fuel, either natural or artificial, available for large engines. The best figures in the table are those obtained in a Sibley College test of a Westinghouse gas-engine and reported by Messrs. Millar and Gladden in the *Sibley Journal* of June, 1900. The power developed was, net, 606 *H. P.*, the mechanical efficiency of the machine 90 per cent., the heating value of the gas about 1,000 *B. T. U.* per cubic foot, the consumption ranging from 10 cubic feet per *B. H. P.* to 8.8 for the indicated power. This gives a thermal efficiency of 25.5 per cent. The same figure is obtained, according to Mr. Donkin's tables, in Mr. Humphrey's test of an engine of a similar power of English make using Mond gas.

The twentieth century opens with the gas-engine for the first time in its century of evolution seriously competing with the steam-engine in important commercial work on a large scale.

R. H. Thurston.

THE U. S. GEOLOGICAL SURVEY.

For the support of the U. S. Geologial Survey for the fiscal year ending June 30, 1902, Congress appropriated at the session just closed about $1,018,000, an increase of $52,000 or more over the present year's appropriation. Indeed, there was a strong disposition in Congress to make a material increase, notably for the extension of hydrographic investigations.

Of the several sums appropriated $250,000 is for the topographic surveys, including a report on the topography and geology of the territory adjacent to the 49th Parallel, west of the 110th Meridian. For the survey of the forest reserves there is $130,000, the same as the present year. For geologic surveys the amount is $150,000—no increase—and for the continuation of the investigation of the mineral resources of Alaska, $60,000. For paleontologic researches there is $10,000. For chemical and physical researches relating to the geology of the United States there is granted $20,000, being $10,000 more than the sum appropriated for the present year. The increase will enable the Director to carry on needful and long neglected physical researches in connection with the chemical work of the Survey. For want of funds the Survey has had no physical laboratory for some years.

For the collection of data and the preparation of a report on the mineral resources of the

United States there will be $50,000, the same as for the present year, but an increase as compared with former years.

The appropriation for gauging streams and determining the water supply of the United States, including the investigation of underground currents in arid and semi-arid sections is likewise the same as this year—$100,000.

With a view to meeting as far as possible a very strong demand from the people for an extension of the hydrographic work of the Survey, there was practical unanimity in Congress in favor of a large increase in the allowance for this work. The increase was provided for in the form of an amendment to the River and Harbor Bill, and hence, like many other items covering meritorious objects, it went down to defeat in the last hour of the session with that now famous measure.

Other items under the appropriation are for engraving and printing, preparation of illustrations, rent of quarters, etc. There is $12,000 for furniture for a new addition to the Survey building in Washington.

Congress also granted upwards of $15,000 to cover deficiencies for the current year.

SCIENTIFIC NOTES AND NEWS.

DR. CHARLES F. CHANDLER, professor of chemistry in Columbia University, has been appointed by the President a member of the Board of Visitors of the U. S. Naval Observatory, in the place of Mr. Clair McKelway, of Brooklyn, who did not accept the position.

THREE expert geologists from the U. S. Geological Survey have been detailed to make a geologic and mineral reconnaissance of the Island of Cuba. They are Dr. C. Willard Hayes, Mr. T. Wayland Vaughan and Mr. A. C. Spencer. Mr. Spencer has not yet started from Washington, but Messrs. Hayes and Vaughan have already reached the island and taken up their work, after conference with the military governor. It is expected that these geologists will accomplish results of distinct economic value to the island. The assignment of these United States geologists to work in Cuba is made at the request of Major-General Wood, the military governor, and of Secretary of War Root, and is with the approval of Secretary of the Interior Hitchcock. The expenses will be met by the Cuban Government.

PROFESSOR S. M. BABCOCK of the University of Wisconsin, inventor of the Babcock milk test, was, on March 27th, presented with a medal, voted him by the State for giving his inventions free to the world. Exercises were held in the Assembly Chamber of the Capitol in the presence of both Houses of the Legislature, the university faculty, Supreme Court, university regents and many prominent citizens of the State. Governor Lafollete presided and addresses were made by him, by ex-Governor W. D. Hoard and others.

AN influential committee has been formed in Italy to celebrate the fortieth anniversary of Professor Paul Mantegazza's entrance on his career as a teacher. This event will be celebrated at Florence on April 30th, and at the same time the thirtieth anniversary of the Italian Society of Anthropology. It is proposed to collect a sum of money to be used for the endowment of the new laboratory of anthropometry which Professor Mantegazza has established at Florence.

THE University of Aberdeen is about to confer the honorary degree of LL.D. on Professor Virchow, of Berlin, and on Major Alfred W. Alcock, superintendent of the Indian Museum, Calcutta, and professor of zoology in the Medical College of that city.

PROFESSOR C. LLOYD MORGAN gave the Croonian Lecture before the Royal Society on March 21st, the subject being 'Studies in Visual Sensation.'

DR. RICHARD R. WETTSTEIN VON WETTERSHEIM, professor of botany at the University of Vienna, has been elected president of the Zoological and Botanical Society of Vienna.

M. HUMBERT has been elected a member of the section of geometry of the Paris Academy of Sciences to fill the vacancy caused by the death of M. Hermite, and M. Normand has been elected a correspondent in the section of geography and navigation in the room of the late General de Tillo.

THE Medical Club of Philadelphia gave a re-

ception on March 29th, at the Bellevue Hotel, in honor of Dr. Charles L. Dana.

THE freedom of the Leathersellers' Company was conferred, on March 15th, on Sir William MacCormac, in recognition of his distinguished services to medical science.

WILLIAM HARPER, who for some years has been the chief of the statistical bureau of the Philadelphia Commercial Museums, has resigned to undertake similar work in London.

WE regret to learn that Dr. Horatio C. Wood, professor of therapeutics in the University of Pennsylvania, and eminent for his contributions to therapeutical and botanical subjects, has been compelled by ill health to give up temporarily his lectures and other work.

THE decoration of the Mérite Agricole has been conferred by the French Government upon the following officers of the Department of Agriculture for services in connection with the Paris Exposition: Dr. H. W. Wiley, chief chemist; Major H. E. Alvord, chief of the dairy division; Col. G. B. Brackett, pomologist; W. A. Taylor, assistant pomologist; M. A. Carleton, cerealist; and John I. Schulte, one of the associatee ditors of the *Experiment Station Record*. The decoration also has been conferred upon James L. Farmer, assistant director of agriculture for the Paris Exposition.

THE Smith's prizes of Cambridge University have been adjudged to Godfrey Harold Hardy, B.A., 4th Wrangler, 1898, scholar of Trinity College, for his essay on 'Definite Integrals of Discontinuous Functions,' and to James Hopwood Jeans, B.A., scholar of Trinity College, bracketed 2d Wrangler, 1898, for his essay on 'The Distribution of Molecular Energy.'

A MARBLE tablet in memory of the eminent French chemist, J. B. Dumas, who died in 1884, has been placed in the house in the rue St. Dominique, Paris, where he formerly lived.

A MEMORIAL marble bust of Robert Brown, the eminent botanist, formerly a student at University of Aberdeen, presented to the University by Miss Hope Paton, has been unveiled in the picture gallery of Marischal College.

THE death is announced of M. Montard, an eminent French mathematician and engineer; of Baron Keiské Ito, professor of botany at the University of Tokyo, who died on January 21st, at the age of ninety-nine years, and of Dr. Peter M. Pokrowski, professor of mathematics at Kiew, on March 3d, at the age of forty-four years.

THE second Latin-American Scientific Congress opened its two weeks session at Montevideo on March 20th, with over 200 delegates in attendance. Dr. Robert Wernicke, professor of pathology in the University of Buenos Aires, Argentine Republic, was elected president of the Congress.

WE learn from the *British Medical Journal* that Professor Robert Koch is staying at Rovigno, on the Adriatic, where he is inspecting the Marine Zoological German Institute, to which he hopes to affiliate a malaria institute for the Istrian district. Koch's late stay in New Guinea has been fruitful in good results, the fight against malaria having been continued energetically on the lines laid down by him. Unfortunately the disease is very prevalent in the German colonies of East Africa. A medical officer with assistants and the necessary scientific apparatus is to be sent out there by the German Government, for which purpose 30,000 Marks have been voted by the Reichstag.

THE Coast and Geodetic Survey steamships *Pathfinder* and *McArthur*, at San Francisco, and the *Patterson* and *Gedney*, at Seattle, are now fitting up und r orders to proceed to Alaska to survey important passages among the islands along the Alaskan coast. The existing charts are based on old Russian ones, corrected from time to time by reconnaissance surveys.

THE Convocation of Oxford University has rejected by a vote of 126 to 125 a resolution to build a house in the Parks adjacent to the observatory as a residence for the professor of astronomy.

SECRETARY WILSON has arranged to carry into effect, on July 1st, the reorganization of certain of the divisions of the Department of Agriculture, as provided by the last Congress. It will be remembered that, in addition to the Weather Bureau and the Bureau of Animal Industry, four new bureaus were created—of Plant Industry, of Forestry, of Chemistry and of Soils.

NEWS has been received from the eclipse expedition sent out by the Massachusetts Institute of Technology to observe the total eclipse of the sun at Sumatra. Professor Burton and his assistants took the Dutch steamship *Konigin Regentes* at Genoa on March 12, and found on this steamer an official expedition sent out by the Netherlands Government. All the instruments were safely placed on board the steamer, which goes directly to Padang.

THE ground occupied by the building of the U. S. Fish Commission, at Washington, has been granted to the Baltimore and Potomac Railroad, and the building will be removed to another part of the Mall, west of its present position. The railway company must pay $40,000 towards the cost of rebuilding.

IT has been announced that Mr. J. P. Morgan was the donor not only of the Tiffany collection of gems and pearls, but also of the Bement collection of minerals and meteorites to the American Museum of Natural History.

THE Department of Zoology and Entomology of the Ohio State University has secured a very interesting and valuable collection of Ohio birds through the generosity of Mr. W. L. Hayden, of Columbus. It includes representatives of a large number of native birds and is noteworthy from the fact that the different species are shown with their natural surroundings, nests, eggs and often young, as well as old, birds of both sexes. Some particularly striking effects are produced with the nests of owls and woodpeckers included in sections of the trees in which they were constructed. The collection is arranged in forty-two handsome cases, finished in oak, and is stated to have cost over one thousand dollars in its preparation, not counting the time, ingenuity and skill which Mr. Hayden has lavished upon it.

THE father and uncle of Dr. Walter Myers, whose life was sacrificed in the study of yellow fever, have given £1,500 to the Liverpool School of Tropical Medicine for the prosecution of its investigations.

PROFESSER WILLIAM OSLER of Johns Hopkins University, has been invited by the management of the Congress of Tuberculosis, to be held in London at the end of July, to arrange for American representation. Among those who have already signified their intention to be present are Professor Truedeau, of Massachusetts, Professor Solly, of Colorado, Dr. Herman Biggs, of New York, Dr. J. G. Adami, of Montreal, and Professor McEachran, of Quebec.

THE American Academy of Political and Social Science will hold its fifth annual meeting at Philadelphia on April 12th and 13th. Professor Samuel McCune Lindsay has been elected president of the Association by the directors in succession to Professor E. J. James, of the University of Chicago, who was the founder of the Academy and its first president, from the date of organization in 1889, until January 1, 1901.

A CIVIL service examination for the position of aid in the U. S. Coast and Geodetic Survey, with a salary of $725, will be held on April 23d. The subjects are mathematics, astronomy, physics, surveying, geography and modern languages.

MR. MARCONI has won the suit brought against him for $100,000 damages and to restrain him from further use of wireless tele graphy by the assignee of Professor A. E. Dolbear.

SENATOR SLATER has introduced a bill, at Albany, appropriating $400,000 for the use of the Palisade Commission in purchasing the Palisades. The first section of the bill is as follows:

> The sum of $400,000, or so much thereof as may be necessary, is hereby appropriated, out of any moneys in the Treasury not otherwise appropriated, for the use of the Commissioners of the Palisades Inter-State Park, to be expended in acquiring land lying between the top of the steep edge of the Palisades of the Hudson River and the high-water line of said river, and lands lying under water and riparian right adjacent thereto between Fort Lee and Piermont Creek, in such name or names and under such conditions as the commission may deem necessary or wise, and for such other purposes as the commission may deem necessary and proper in carrying out the purposes and intent of Chapter 170 of the Laws of 1900.

THE Ways and Means Committee of the Assembly of New York State has reported the bill of Assemblyman Snyder, appropriating $250,000 for the purchase of forest lands for the State preserves. Of the sum appropriated $200,000 is to be expended in the purchase of

land for the Adirondack preserve and $50,000 for the Catskill Mountains preserve.

The Legislature of New Hampshire has rejected two bills for the preservation of the State forests. One bill provided for the restriction of lumber cutting to trees of a prescribed size. The other bill authorized a loan of $1,000,000 for the purchase of forest lands and the establishment of a forest reserve in the State.

At the last monthly meeting of the Zoological Society of London, it was stated that there had been 118 additions to the Society's menagerie during the month of February, amongst which special attention was directed to an August amazon (*Chrysotis augusta*) from Dominica. Upon one previous occasion only had a specimen of this fine bird been received at the Society's gardens—namely, on May 12, 1865. The additions also included a Guinea fowl (*Numida meleagris?*) from Rabat, Morocco, presented to the Society by Mr. G. E. Neroutsos, British Vice-Consul at that port. The Council announced to the meeting that the King had been pleased to become patron of the Society in succession to the late Queen Victoria.

In order to further laboratory instruction of large classes of students in physiology, Professor W. T. Porter, director of the physiological department in the Harvard Medical School, will undertake to provide reliable physiological apparatus constructed under his personal supervision. It is expected that the improvements suggested by the daily experience of the Harvard Laboratory will thus be made directly available to others; and it is hoped that by this arrangement the quality of physiological apparatus for general use will be improved and the price sensibly diminished. All communications should be addressed to Professor W. T. Porter, 688 Boylston Street, Boston, Mass.

The following details are given in *The Forester* regarding the Act passed by the Pennsylvania Legislature which raises the Division of Forestry of the State's Department of Agriculture to the position of a Department of Forestry. In addition to the new importance which is thus given to the forest service of the State, the efficiency and strength of its organization is much increased by the Act. The department is to consist of a Commissioner of Forestry, and four others. These shall also constitute the State Forestry Reservation Commission. The commissioner is to hold office for four years and so are his fellow members of the Reservation Commission; they are not all to be appointed at the same time, however, and their terms of office so overlap that the Board will always have two members of two years' experience. The Reservation Commission is empowered to buy lands for the forest reserve, to manage them, to sell timber and to make contracts for the mining of any valuable minerals which may be found in them. The Act further specifies that the Commissioner of Forestry shall be the president and executive officer of the Forestry Reservation Commission, and also superintendent of the State Forestry Reservation, and shall have immediate control, under the direction of the Commission, of all forest lands belonging to the Commonwealth. He is empowered to execute all rules adopted by the Commission for the enforcement of laws designed to protect the forest from fire and depredation, and is also empowered to employ detective service and to make arrests. It is also provided in this Act that the kindling of fire on a forest reservation, except in accordance with the rules and regulations of the Commission, shall be a misdemeanor, for which the penalty is a fine of not less than one hundred dollars, or more than five hundred. Governor Stone has appointed, as we have already noted, Dr. J. T. Rothrock as Commissioner.

At the annual general meeting of the Institution of Mechanical Engineers, London, Mr. W. H. Man was elected president, Mr. A. Keen, Mr. T. Hurry Riches and Mr. Bryan Donkin, vice-presidents and Sir J. Wolfe-Barry, Mr. W. Dean, Mr. H. G. Harris, Mr. A. Tannett-Walker and Sir W. T. Lewis, new members of the council. The annual report, as we learn from the *Times*, stated that at the end of 1900 the number in all classes on the roll of the institution was 3,165, a net gain of 243 members as compared with the number on the roll at the end of the previous year. The total revenue for 1900 was £9,005

8s. 1d., while the expenditure was £8,595 11s. 1d., leaving a balance of revenue over expenditure of £409 17s. The total investments and other assets at the end of the year amounted to £70,117 1s. 5d., and, deducting therefrom the £25,000 of debentures and the total remaining liabilities, £4,211 15s. 6d., the capital of the institution amounted to £40,905 5s. 11d. Of this sum £5,000 was set aside in 1897 and 1898 for the redemption of the debentures. The sum of £6,850 4s. 8d. still remained invested in railway debenture stocks and Consols, registered in the name of the institution. A total of £60,270 2s. 10d. had now been expended upon the institution-house. The award of the Willans Premium had been for the first time in the gift of the council, and, from the papers read before the institution since the foundation of the fund in January, 1895, they had selected that read in April, 1895, by Captain H. Riall Sankey, on 'Governing of Steam-engines by Throttling and by Variable Expansion,' as the most suitable for the award. With a view to the formation of a historical museum, relating to mechanical engineering progress, several gifts of value had been promised. The numerous letters which had been received from the United States evinced a thorough appreciation of the reception accorded to the members of the American Society of Mechanical Engineers by the institution at its summer meeting. The work of the graduates has been carried on with considerable success, and a number of visits were made by the graduates to works in the neighborhood of London. The council had awarded prizes to Mr. W. B. Cleverly and Mr. Brees van Homan for their papers on 'Works Management, Methods of Quick Production of Repetition Work' and 'Steel Skeleton Construction, as applied to Buildings on the American System' respectively. In consequence of a desire expressed by several members of the institution, the council communicated with the War Office in February, asking if it would be of any advantage to the Government to have the assistance in South Africa of the engineering experience of members of the institution; the reply indicated the high appreciation of the Secretary of State for War, and stated that, although arrangements had already been made, the offer would certainly be borne in mind in case circumstances should alter. The council, after consultation with officers of other institutions, had consented to take charge of the mechanical section of the Glasgow International Engineering Congress, the meetings of which would be held during the first week of September of this year. These arrangements would not interfere with the ordinary summer meeting of the institution, which would be held during the last week of July at Barrow-in-Furness.

THE home department of the Government of India has made a report of deaths from wild animals and snakes which are summarized in the London *Times*. During 1899 the number of deaths among human beings attributed to wild animals was 2,966. Fortunately, however, the number is below the average of the last four years and much lower than the number (4,283) reported in 1897. In 1899 tigers caused the death of 899, wolves of 338, and leopards of 327 human beings, while bears, elephants, hyenas, jackals and crocodiles were accountable for a large proportion of the remainder. The tiger is most destructive in Bengal, about half of the whole number of the victims of this animal being reported from that province. Man-eaters have especially troubled certain districts, and liberal rewards have been offered for their destruction. In the Bhamo district of Upper Burma a single man-eating tiger killed about 20 people. A special reward of 100 rupees was paid for its destruction. More than half of the deaths from leopards occurred in Bengal, while more than three-fourths of those from wolves occurred in the Northwestern Provinces and Oudh. Special measures were taken to hunt down a particularly destructive pack near Cawnpur. High rewards were offered, and hunting parties organized, but without much success. The loss of human life from snakes reached the high total of 24,621 a greater mortality than in any of the four preceding years. Nearly half the deaths occurred in Bengal, while the Northwestern Provinces and Oudh came next with nearly one-fourth of the total. In Bengal the relatively high mortality is attributed to floods, which drove the snakes to the highlands on which village homesteads are built. As will be observed, snakes are more

destructive of human life than are wild animals, but the reverse is true of the destruction of cattle. In 1899 no fewer than 89,238 cattle were destroyed by wild animals, and 9,449 by snakes. Of the former 37,986 fell victims to leopards, and 34,321 to tigers. The leopard is even more destructive to cattle than the tiger in Bengal. This province is the greatest sufferer from the ravages of wild animals and snakes, its loss being 30,539 cattle. Assam lost 17,010, Madras 15,592, Burma 11,016, and the Central Provinces 11,689. The number of wild animals destroyed was 18,887 and the amount paid for their destruction was 107,476 rupees. The number of snakes killed was 94,548, and the rewards paid for service amounted to 4,151 rupees.

UNIVERSITY AND EDUCATIONAL NEWS.

THE Washington State Legislature has adjourned after having made liberal appropriations for the support of education. The State University gets $270,000, the State Agricultural College $94,800, the three normal schools $93,800, $45,000 and $40,000, respectively.

THE Indiana Legislature has appropriated $100,000 for a science building for Indiana University.

THE Ontario Government, in addition to the aid contained in the Toronto University Bill now before the Legislature, which involves the payment of about $20,000 a year for the science department, salaries and maintenance, has decided to erect a new building for the science department on the site of the old Wycliffe College, at a cost of about $200,000.

BY the will of the late George T. Bliss, of New York City, who died on March 24th, Yale University receives $50,000.

MR. JOHN D. ROCKEFELLER has offered to give Richmond College, a Baptist institution of Virginia, $75,000, on the condition that the College shall collect $25,000.

THE sum of $12,000 per annum has been subscribed for the conduct of the experimental school of Teachers College, Columbia University. It will be remembered that a building is about to be erected for this school with a gift of $100,000.

THE Lord Mayor of London presided at a meeting on March 21st, when the Earl of Roseberry delivered an address on commercial education. The object of the meeting was to call attention to the importance of higher commercial education in relation to the present position and prospects of British trade, and to take the preliminary steps to raise a fund for the establishment of additional higher commercial teaching in connection with the new London University. Toward this fund, Messrs. N. M. Rothschild & Sons have contributed £5,000.

AN influential committee has issued an appeal with the object of raising £150,000 in celebration of the jubilee of Owens College, Manchester. Fifty thousand pounds are needed to discharge debts that have been contracted and £100,000 for additional endowment. Among the objects the promoters have in view are the extinction of the debt of £22,000 on the building of the medical school; special endowments for existing chairs, including French, chemistry, education, anatomy and philosophy; the establishment of new chairs of English literature, Hebrew and architecture; the establishment of an institution for bacteriological investigation and for the study of hygiene, and of research fellowships; and the creation of a pension fund for members of the teaching staff.

FOLLOWING the action recently taken by the University of Michigan, the Faculty of the College of Science, Literature and the Arts in the University of Minnesota has voted to recommend to the Board of Regents that only one degree, that of bachelor of arts, be given hereafter. Under the present arrangement three courses are offered in the college, leading to the degrees of bachelor of arts, bachelor of literature and bachelor of science.

FOR the remainder of the college year, Mr. S. M. Coulter takes the position of instructor in botany in Washington University, vacated by the appointment of H. F. Roberts as professor of botany in the Kansas Agricultural College.

DR. V. L. LEIGHTON, instructor in organic chemistry at Tufts College, has been called to an associate professorship of chemistry at the College of Agricultural and Mechanic Arts, at Kingston, R. I.

George M. Dawson